Tailoring Deactivation & Decommissioning Engineering/Design Activities to the Requirements of DOE Order 413.3A

Volume I

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1. INTRODUCTION

The Department of Energy and the Office of Environmental Management have recognized the critical importance of a robust and disciplined approach for nuclear facility construction projects leading to the conduct of conceptual designs at Critical Decision-1; preliminary designs for the performance baseline at Critical Decision-2; and the approved start of construction at Critical Decision-3. This is exemplified by important, substantial and numerous dialogue and technical development during 2006 and 2007, resulting in guidance and direction to better integrate safety into design of projects early in the life cycle; specifically to ensure that safety issues are addressed early in the overall design process[1]. As such, the conceptual and preliminary designs must be sufficiently mature to have addressed and analyzed projected safety systems. The culmination of these efforts is the April 2008 issuance of DOE-STD-1189, *Integration of Safety into the Design Process*[2].

The specific focus of this effort and concomitant standard addresses the adequacy of conceptual and preliminary designs for nuclear facility construction projects; it is however clear that this approach and philosophy is equally applicable to the conduct of deactivation and decommissioning projects. Similarly, applying the approach and philosophy of DOE's project management order (DOE O 413.3A, *Program and Project Management for the Acquisition of Capital Assets*) to the technical aspects of deactivation and decommissioning projects provides the opportunity to improve the entire scope of technical planning, engineering, and design for these projects; resulting in the iterative, sequential development of more detailed and dynamic conceptual, preliminary and final designs.

One central theme is apparent: EM management has placed a renewed interest in, and expectation for, enhanced rigor in the planning and engineering/design of its projects, including those for deactivation and decommissioning. This expectation raises the bar and makes clear that "business as usual" is not acceptable; the guidance provided in this document is intended to assist in the implementation of these stated expectations.

1.1 Purpose

DOE O 413.3A, defines three sequential phases of design (conceptual, preliminary, and final) that coincide respectively with Critical Decisions -1, -2 and -3 (CD-1, -2, -3). Regardless of the fact that there are many differences between D&D[3] and the design-build model upon which the order is based (see Section 1.2), meeting the *intent* of the CD milestones and satisfying the requirements of the order is essential. Conducting engineering/design and creating the related documentation must be accomplished to a sufficiently increasing level of detail at each stage to: 1) create a project's conceptual design; 2) develop a preliminary design sufficient to establish a high confidence baseline; and 3) establish a final design ready for implementation. As used here, "design" in the context of DOE 413.3A represents a broad perspective that includes all of the many types of D&D technical planning and engineering.

> This guidance serves as a tool for use in D&D project planning and provides a roadmap and process for evaluating and integrating engineering and design into the project baseline and execution.
>
> The degree of applicability and its use is the responsibility of the Federal Project Director (FPD) and the Integrated Project Team (IPT), understanding that the primary objective is to provide sufficiently detailed technical input needed for the project's scope, schedule, and cost baseline.

To ensure development of appropriate levels of engineering detail, DOE-EM's Office of Deactivation and Decommissioning and Facility Engineering (EM-44) has prepared this guidance for

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[1] Memorandum for Distribution, Dr. Inés R. Triay, *Interim Guidance on Safety Integration into Early Phases of Nuclear Facility Design*, July 18, 2006.
[2] This guidance document does not address safety as a primary subject. See DOE-STD-1189 for details of its application.
[3] As described in definitions in Section 6, D&D should be taken in a general context.

tailoring a D&D project's engineering/design to meet the objectives of the CD milestones. The enhanced rigor in planning and systematic, forward looking approach to engineering/design recommended in this guidance is intended to ensure that the level of detail in technical planning and technical development, integrated with other project aspects such as safety basis modifications, leads to a high confidence that the engineered system as a whole will function as designed. As the level of detail iteratively increases as D&D project development progresses and matures from CD-1 through CD-3, the extent of uncertainty and risk proportionally decrease and a measurable improvement in project definition, quality, and confidence in the baseline is established.

Project Scope Context for this Guidance

Single projects within DOE-EM often encompass many large and small facilities, either by contract or as a Project Baseline Summary (PBS); in many of these, the CD process is applied on this larger scale. Users of this guidance need to understand that engineering/design progress addressed in this guidance is to be applied at a level usually associated with a major facility, its ancillary structures, and its associated systems. Similarly, those conducting CD project reviews and providing recommendations to senior decision makers must clearly understand that it is generally counter-productive to hold up the start of field work until the CD process has been completed for all of a large group of facilities that comprise a PBS or contract scope.

For situations in which major engineering tasks (e.g., characterization) and related decisions are delaying the CD process, one approach is to manage the sequence of critical decisions to obtain a "CD-3A" approval to start field work for a specific facility's D&D scope while the overall CD-2/3 process continues for the total PBS or contract scope. Another approach would be to approve a combined CD-2/3 package at the PBS or contract level and utilize facility-specific requirements that subsequent reviews be conducted of the engineering/design aspects for each major facility prior to approval to commence substantial D&D field work. Precedents for both these approaches have been established.

Organization of this Guidance

This guidance document is organized into two volumes. Volume I contains the guidance and is comprised of the following six sections:

- Section 1 provides the background and the purpose, and lists related guidance.
- Section 2 relates the design phase language of DOE O 413.3A to D&D engineering/design and suggests an overall approach to meeting the intent of the order, as well as DOE-EM management's expectations for a high confidence project baseline.
- Section 3 presents a Project Management[4] decision framework for tailoring engineering/design activities to D&D projects, including recognition that most field work and its related engineering support does not follow the classic design-build type of schedule.
- Section 4 provides a method for selecting D&D project activities for which a high level of engineering/design detail is important for achieving a reliable, well-defined baseline.
- Section 5 provides independent reviewers with perspectives for D&D engineering/design activities and deliverables.
- Section 6 includes definitions and acronyms used in this guidance.

Volume II contains example material that illustrates application of the guidance, but is not specifically guidance, per se. The sections are:

[4] Within this document, the use of "project management" refers to the Integrated Project Team (IPT) that includes the Federal Project Director, EM field managers, and contractor project managers.

- Section II-1 describes engineering/design levels of detail for 48 activities typical of D&D projects.
- Section II-2 provides independent reviewers with example lines-of-inquiry for D&D engineering/design activities and deliverables.
- Section II-3 contains a fictitious example of a project to which the process in Section 4 has been applied to demonstrate use of the method.
- Section II-4 contains an example of a single activity (#10, Equipment Removal) that is fully developed with regard to describing deliverables input to the WBS and schedule logic that can be used to support baseline development.

1.2 Differences between D&D Engineering/Design and Design-Build Projects

D&D projects are subject to DOE O 413.3A, and for the purposes of this guidance, specifically to the "design" requirements. However, the order was developed based on new construction capital projects, which differ considerably from D&D. Generally, new construction projects benefit from a large number of "known" attributes related to planning, design, engineering, physical construction (how big, how many floors, how many rooms, etc.), and the type, size and capacity of systems (process, utility, support systems). Conversely, D&D projects are frequently characterized by several "unknown" attributes, which in many instances represent significant risks for the project baseline. However, some D&D projects also have the benefit of knowledge of original designs, modifications, as-built drawing (to some degree), facility operating history, contamination measurements, etc.

Although the end-state[5] of a D&D project is generally determined at the onset of project planning and within a context of area-wide and site-wide decisions, requisite knowledge of facility physical conditions (e.g., building structural integrity, system configuration, or accessibility limitations due to radiation or contamination) and the types and extent of contamination may not be available. Obtaining the information needed will often require a step-wise, iterative process as project planning matures.

Much of the engineering efforts in facility construction projects are devoted to classic design tools, such as development of drawings, specifications, calculations, analyses, evaluations and application of codes and standards. For D&D projects, the fraction of the engineering effort devoted to classical design tools is typically much lower (may be zero) and is rarely significant. In general, the following differences are noted:

- There is relatively little traditional design work for new systems, structures, and components (SSCs) for D&D. The amount of engineering leading to design drawings and specifications is usually limited to reconfiguring systems or structures to support worker habitability and is relatively small compared to the overall project scope. Such design efforts would generally be a minor factor and review consideration in the CD process for a D&D project. (An exception is for cases when major refurbishment or SSC modifications are a required pre-requisite to D&D.)
- D&D involves a significant amount of engineering. The types of engineering tools, however, are for the most part different from design-build engineering. Deactivation of equipment and systems, equipment removal, demolition, operational safety analyses, and material stabilization are a few examples of D&D activities for which engineering is practiced. In addition to the traditional structural, mechanical, chemical, and electrical disciplines, skills required will in many cases also include nuclear safety and radiological engineering.

[5] In simple terms, "end state" can be deactivation followed by long-term surveillance and maintenance, or demolition, or in-situ decommissioning (entombment), the latter two followed by free release or by long-term institutional control.

- D&D tends to be heavy in operations and services types of work and light on fabrication or new construction, resulting in a labor mix that is very different from construction. Also, with the exception of decommissioning equipment (e.g., excavators, cutting equipment), the need for new equipment is low. The need for materials is heavily weighted towards consumable items, much of which will become radioactive or hazardous waste.
- Pre-existing conditions may be extremely variable from facility to facility because of differences in vintage of construction and nature of operations that have been conducted.

Another difference worth noting is that, unlike traditional engineering that is done predominantly by an engineering "department," many D&D engineering tasks use workers to provide input and feedback during engineering/design. This approach to project development utilizes facility operating experience as well as serving the objectives of Integrated Safety Management and readily fits in with the iterative approach recommended by the guidance provided within this document.

As already mentioned, but to reiterate this guiding principle; regardless of these differences, meeting the intent of the critical decision process and milestones is essential to preparing documentation of appropriate and sufficiently increasing level of detail to support each critical decision stage and to satisfy the requirements of DOE O 413.3A.

1.3 EM Approach to Capital vs. Operating Budget

In June 2009, EM management initiated a strategy that clearly differentiates EM capital asset projects from non-capital asset activities that include EM programs and facility operations. The highlighted box that follows describes the strategy as it applies to D&D.

This new strategy does not negate the principles in this guidance related to establishing sufficient engineering/design that supports a high confidence baseline. However, reviews of the operational phases of a project, such as for deactivation, will only be conducted by EM for appropriate engineering/design. The capital asset phase for decommissioning will continue to be subject to external reviews by the Office of Engineering and Construction Management (OECM) as well as within EM.

Memorandum[6] Excerpts

Capital asset projects being executed as cleanup projects involve the construction phase of environmental restoration (i.e., soil and water remediation) and facility decommissioning and demolition.

Operations includes non-capital asset activities including: the stabilization, packaging, storage, transportation and disposition of waste and nuclear materials; the operation of environmental remediation systems such as groundwater treatment systems; post-construction and post-closure care of remediated land burial sites; long-term environmental stewardship including environmental monitoring and institutional controls; and facility shutdown and deactivation activities designed to place the inactive structures, systems and components in a safe and stable configuration pending final decommissioning.

One significant intended effect of this strategy is to make more efficient the approval process for those portions of D&D projects that are operationally funded by modifying the external review cycle as specified by DOE O 413.3A. However, EM will continue to embody the Order's principles in the conduct of business operations. This new structure is based on, and more succinctly aligned with, existing Federal and Departmental asset management requirements.

[6] This is addressed in a June 5 memorandum from Ines R. Triay, Assistant Secretary for Environmental Management to Ingrid Kolb (Director, Office of Management) with a subject of "Restructuring Office of Environmental Management Projects."

1.4 Design Phase Completion Progress

Traditionally a design-build project's overall design roughly corresponds to 30%, 60%, and 90% at the end of the conceptual, preliminary, and final design phases, respectively. However, the overall status of design completion does not require that all individual design disciplines be at that state. For example, at CD-2, the civil structural deliverables of a design-build project may be 80% to 90% complete when the electrical design may be, say 30%.

DOE M 413.3-1 is not prescriptive regarding percentage completion for the respective design phases. It recognizes that there is wide variation among projects. This recognition in the manual is in fact the case for a D&D project; the number of drawings cannot estimate the percentage of completion and other deliverables completed. This guidance identifies technical deliverables when planning or reviewing progress equivalent to conceptual, preliminary, and final design status. The overriding point, however, is that there must be technical specificity at these design milestones. Conceptual development cannot simply be a discussion of D&D principles and generalities; it must represent a state of technical development that represents approximately 20% to 30% completion of engineering/design. In addition, the level of detail for baseline development must be proportionately greater.

1.5 Related Guidance

This guide does not replace other existing guidance and is to be used in combination with other DOE guides and handbooks that address D&D related work, including those listed below:

- DOE G 430.1-2, Implementation Guide for Surveillance and Maintenance during Facility Transition and Disposition (Sept. 1999)
- DOE G 430.1-3, Deactivation Implementation Guide (Sept. 1999)
- DOE G 430.1-4, Decommissioning Implementation Guide (Sept. 1999)
- DOE G 430.1-5, Transition Implementation Guide (Apr. 2001)
- DOE G 413.3-8, EM Clean-up Projects (Sept. 2008)

2. D&D Conceptual, Preliminary, and Final Design

This section recommends approaches and suggests levels of detail for D&D project engineering/design that will meet the intent of DOE O 413.3A requirements. Figure 1 illustrates the theme of this guidance, which is to start early development of D&D projects' technical detail to create a comprehensive technical project concept at CD-1 and to increase the level of detail sufficiently to provide a reliable scope, schedule, and cost performance baseline at CD-2, and to be ready for implementation at CD-2 or CD-2/3.

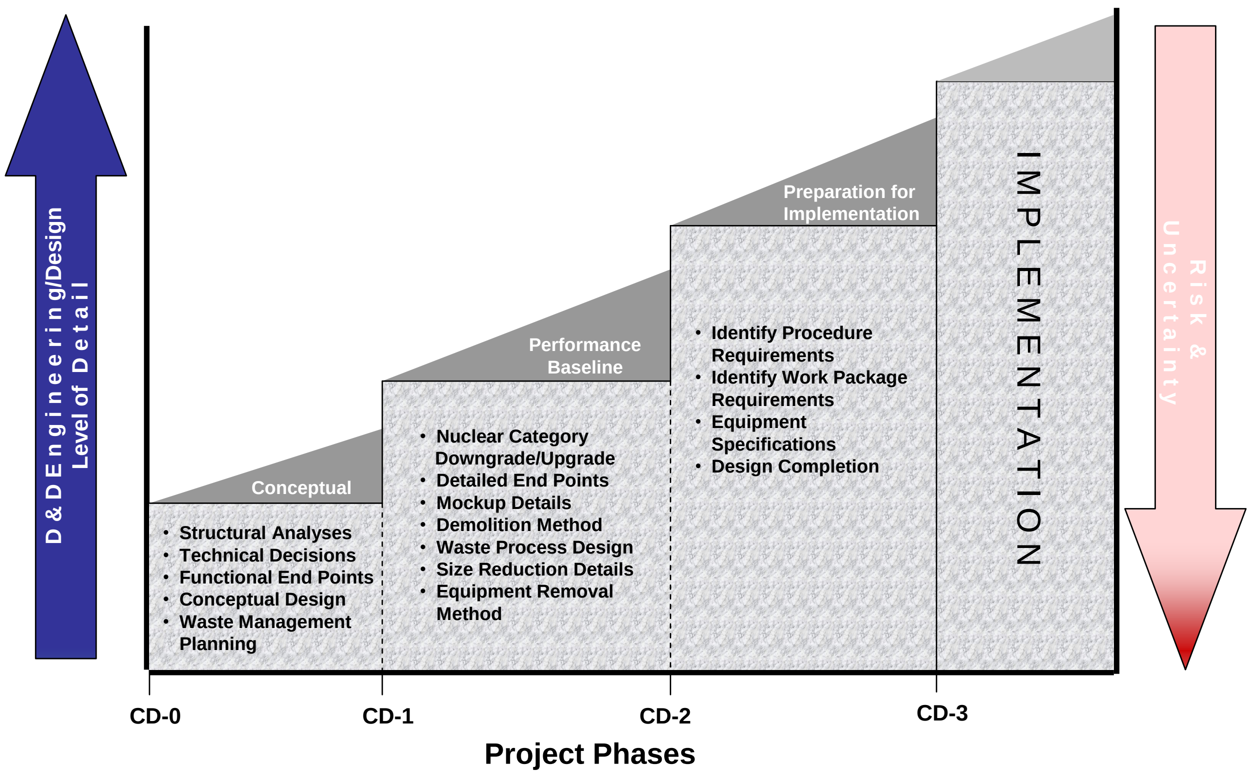

Figure 1 – Overview of D&D Engineering/Design Increasing Level of Detail

This guidance recognizes that many D&D project engineering/design activities are conducted after CD-3. Nevertheless, it is important to identify project activities for which a high level of technical detail is needed at CD-2/3. Sections 3 and 4 address identification of such activities. . (For a more detailed understanding of the relationship between different CD levels see DOE Order 413.3A Guide 8 Attachment 3)[7]

Note that the bulleted lists in the figure are examples; more complete examples are provided in this section and Volume II.

Section Approach

This section relates engineering/design typical of D&D projects to the requirements of DOE O 413.3A by first citing the order's language followed by a recommended approach. Section 2.1 describes how following this guidance for a D&D project can meet the "systems engineering" requirements of DOE O 413.3A. The subsequent three subsections recommend an approach to complying with the Order for a

[7] U.S. Department of Energy, Environmental Management (EM) Cleanup Projects: DOE Order 413.3-8, April 24, 2008, pg. 61

D&D project's conceptual, preliminary, and final design phases and their related critical decisions. In Section 2.5, the order's engineering phases are compared with similar phases defined by CERCLA.

Combining Critical Decisions

Many D&D projects combine CD-1/2 or CD-2/3 when there is relatively little technical development needed between the two decision points. In some cases, a combined CD-1/2/3 can be appropriate for a facility with low hazard and complexity. In these cases, the level of detail described in Section 2 for CD-1 and CD-2 is applicable for a combined CD-1/2; and similarly to a CD-2/3 combined approach. Combining Critical Decisions and structuring of related project reviews and approvals is the responsibility of the Federal Project Director and the Integrated Project Team (IPT), taking into account the project's complexity.

2.1 Integrated Systems Engineering Requirements

DOE O 413.3A Statements[8]

Section 5.2.3 of DOE M 413.3-1, *Project Management for the Acquisition of Capital Assets*, defines Systems Engineering as follows: A system is an integrated composite of people, products, and processes that provides a capability to satisfy a need or objective. Systems engineering is an interdisciplinary collaborative approach that is accomplished by integrating three major elements:

- Development phasing that controls the design process and provides baselines that coordinate design effort
- A process that provides a structure for solving design problems and tracking requirements flow through the design effort
- Life-cycle integration that involves users in the design process and ensures that the developed product is viable throughout its life

Each of these elements is necessary to achieve proper management of a development effort. The primary goal of the systems engineering process is to transform mission operational requirements or remediation into system architecture, performance parameters, and design details. The application of systems approach is tailored to the project's needs. A project need not be a system to use a systems methodology. Systems engineering is a tool that consists of iterative processes, such as requirements analysis, alternative studies, and functional analysis and allocation.

Recommended Approach

This guidance serves as an element of system engineering by tailoring the approach and deliverables for project technical planning and engineering/design of D&D projects. This is accomplished as follows with regard to the three elements above:

- Tailoring the approach to conceptual, preliminary, and final design to D&D projects provides the basis for meeting the first element. This includes activities such as recognizing the need for up-front characterization and technology development discussed in Section 3.4, and prioritizing significant engineering/design activities that must be done early and thoroughly to support a reliable baseline.
- DOE and contractor qualified project planning and engineering staff applying systematic management control procedures, for which incorporating this guidance is only one element, serves the second element.
- With regard to the third element, because D&D projects are beyond the end of the mission of a facility, the life cycle element stated above (from the manual) applies to the D&D life cycle. The "users" of a D&D project are the deactivation, demolition, and closure teams that conduct the

[8] DOE O 413.3A statements in Sections 2.1 through 2.4 are verbatim quotes.

work. In all D&D projects, these users are very much involved in providing input to the technical planners and engineering/design staff.

2.2 Conceptual Design Phase, Approve Alternative Selection and Cost Range, CD-1

DOE O 413.3A Statements

The description for CD-1 in DOE O 413.3A is:

> "CD-1 approval marks the completion of the project Definition Phase, during which time the conceptual design is developed. This is an iterative process to define, analyze, and refine project concepts and alternatives."

The specific DOE O 413.3A requirement is:

> "Prepare a Conceptual Design Report which is an integrated systems-engineering effort that results in a clear and concise definition of the project. [9]"

Recommended Approach

The Conceptual Design Report (CDR) should describe the D&D end state, identify technical challenges that are extraordinary or require special attention (see Section 4.2), and present the overall technical approach to the project as reflected in technical planning results. Equally important; the CDR should describe what is known about the facility/D&D project (characterization, extent of contamination, physical/structural integrity, systems dependence/interdependence, etc.), what is not known, and how each affects the confidence in the engineering/design discussed in the CDR. As appropriate, the plans, schedule, etc., for compiling data acquisition needed to decrease project design uncertainty should be provided in the CDR.

The CDR will likely be a summary of the detailed results of technical planning, engineering, and design, all of which would be too massive to include in a single document. That is, the CDR can be a "road map" to much of the detail that is contained in other documents. Regardless, the CDR document must contain a cohesive technical description at a level of detail for meaningful review and clear comprehension of specifics. It must provide confidence appropriate to this stage of project technical development and should reference the documents that provide the bases for the concepts described.

It is essential that the detailed results of the conceptual design be maintained and available as needed for follow on work as well as for reviewers, just as would be the case for a design-build project.

Providing the level of detail recommended in the following discussions can result in a conceptual design sufficient for a rough order of magnitude cost estimate[10] that will support the needs of project definition at CD-1.

It should *not* be assumed, as has been suggested, that a proposal prepared for D&D project in response to an RFP provides sufficient detail for CD-1. The project team has the option of reviewing an accepted proposal and deciding which parts can be incorporated in the conceptual design.

Engineering/design activities listed below for the conceptual and preliminary design phases are grouped as *Technical Planning* and *Engineering/Design*. The difference is that Technical Planning primarily supports decision making, contrasted with engineering/design that directly creates design deliverables for implementation. Both involve technical activities performed by engineers (as well as other project staff, with input from field workers) and both are equally important in sequentially creating, analyzing,

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[9] It is important to reiterate and understand that while the conceptual design report can first address the overall project consisting of many facilities, it must also "drill down" and initiate the conceptual design process for individual facilities of significance within the broader project.

[10] For D&D projects, rough order of magnitude estimates (ROM) represent a range of uncertainty generally given as -25% to +75%; however, this will depend on the project's scope, stage of estimate, degree of unknowns, as well as the estimating organization's standard practice.

describing, and presenting project concepts integrated into system level solutions. With regard to technical planning, the appropriate level of detail depends on the nature of the project and which of the facility's characteristics, type and degree of contamination, structures and systems, etc., are important for project definition. With regard to engineering, the level of detail is functional (e.g., "identify") for CD-1. During conceptual development the project team needs to identify those engineering/design activities that are important for the baseline.

Technical Planning – Getting to CD-1 requires considerable technical planning. Examples of technical planning during this phase include:

- Specifying end points for systems, spaces, and outbuildings and features; that is, conditions to be achieved, whether for deactivation or for decommissioning[11]. End points refer to detailed specifications; typically they specify systems as remaining operational, to be isolated and abandoned, or preserved for possible future use (i.e., "mothballed"). Similarly, the status of spaces is typically specified as being accessible for surveillance and maintenance or "access not necessary." The status of ancillary buildings and structures is variable. At the conceptual stage, end points functionally state "what" is to be achieved; "how" they are to be implemented is the follow-on design effort leading to CD-2 and beyond.
- Identifying longer term monitoring systems, as applicable for a specified time period, where end states include "leave-in-place" conditions.
- Evaluating the need to revise the Authorization Basis (A/B) and conducting the supporting safety analyses. Establishing the conditions for the A/B change, such as fissile material removal, may be conducted prior to commencing field work following CD-3. In particular, the guidance in DOE-STD-1189, *Integration of Safety into the Design Process,* should be used for a nuclear safety design strategy and specification of nuclear safety analytical methods.
- Describing the selected decommissioning alternative. In some cases this may be a result of a Record of Decision for a CERCLA action. In the case of a project that includes deactivation, the overall end state vision should be described.
- Evaluating sufficiency of characterization data to decide on D&D methods, major equipment needs, technological challenges, radiation protection issues, and other project considerations.
- Evaluating and identifying the scope of anticipated overall characterization efforts needed for regulatory compliance, worker protection, and waste management. In some cases, a major effort may have preceded the current project to obtain characterization data.
- Specifying the overall physical conditions to be achieved for decommissioning completion (e.g., grouted basement, slab-on-grade) and the criteria for acceptable levels of contamination that may remain to meet the completion requirements.
- Identifying waste streams, estimating quantities by type, and identifying disposition pathways. Wastes without a disposition pathway need to be highlighted along with how they are to be addressed.
- Identifying new SSC installations or existing SSC modifications to support worker habitability and intended methods for D&D.
- Identifying anticipated prototypes, mockups, and/or proof of application for technology development that will be needed to arrive at preliminary designs, tool application, or operational methods.

[11] The end points method is a way to translate broad mission statements into explicit goals that are readily understood by engineers and craft personnel who do the work.

- Identifying the scope of equipment to remain and that to be removed prior to facility demolition, major dismantlement, or in-situ decommissioning. (This provides input to developing end points specifications.)

Engineering/Design – In addition to technical planning, the CDR should also include the results at a conceptual level that describe the "what" of the technical features of the project, but not necessarily the details of "how" these features will be implemented. Conceptual engineering/design deliverables can take a variety of forms that include evaluation results and recommendations, calculations, written descriptions, tabulations, sketches, marked up facility drawings, and others.

Examples of D&D engineering/design activities for CD-1 include:

- Identify the scope of facility isolation including building systems to be isolated and/or abandoned.
- Identify scope of modifications to current facilities and/or temporary systems needed for electric power, breathing air, and ventilation to support D&D work.
- Identify facility areas and portions of systems where decontamination and flushing will be required.
- Identify need for fixatives and primary locations where fixative will be required.
- Identify anticipated floor, roof, and wall structural evaluations and engineering needed to support D&D work.
- Identify locations and operations for which shielding and extraordinary radiation control measures are anticipated to be needed, along with the characterization information that provide the bases.
- Identify scope of size reduction efforts needed for equipment removal.
- Evaluate by computer simulation potential airborne releases based upon approved remaining contaminant levels to demonstrate acceptability of the potential release.
- Specifying methods for in-situ nondestructive assay (NDA) for residual nuclear materials.

2.3 Preliminary Design Phase, Approve Performance Baseline, CD-2

DOE O 413.3A Statements

The description for CD-2 in DOE O 413.3A is:

> "Completion of preliminary design is the first major milestone in the project Execution Phase. Preliminary design is complete when it provides sufficient information for development of the Performance Baseline in support of CD-2. The Performance Baseline is developed based on a mature design, a well-defined and documented scope, a resource-loaded detailed schedule, a definitive cost estimate, and defined Key Performance Parameters. Approval of CD-2 authorizes submission of a budget request for the total project cost."

The specific DOE O 413.3A requirement is:

> "Prepare a Preliminary Design. This stage of the design is complete when it provides sufficient information to support development of the Performance Baseline."

Recommended Approach

Simply put, the goal of CD-2 is to establish a baseline scope, cost, and schedule at a level of confidence sufficient for approval and budgeting, regardless of the nature of the project. This is the phase where execution plans, cost analyses, and schedules are refined and finalized. Project risk management analyses and plans during this phase can identify critical engineering/design issues. Providing the level of detail recommended in the following discussions can result in a preliminary design equivalent to that needed for the performance baseline.

A well-documented basis of estimate (BOE) is also needed. In the case of a D&D project, the BOE will include technical assumptions in addressing the project activities, such as those in Volume II, Section 1, and others important to the project. Compared with a design-build project, most D&D basis-of-estimates will have considerably more labor cost elements and considerably different materials cost elements (i.e., little materials of construction and much greater consumables and disposable materials).

Technical Planning – As with the CDR, preliminary design may require a considerable amount of technical planning to create the project baseline. Technical planning tasks during this phase include:

- Specifying how each deactivation and decommissioning end point is to be physically achieved.
- Creating a post-deactivation surveillance and maintenance (S&M) plan for purposes of deciding the specifics of end points for a deactivation project, in particular if the facility is to be in an S&M mode for an extended period of time.
- Creating plans that provide details of work sequences for removal of equipment and materials, and for demolition or closure.
- Evaluating characterization data for purpose of planning, engineering and specifying equipment selection, radiological safety, decontamination, size reduction, equipment removal, and other field work. Site data is considered when it affects activities (e.g., meteorology constraints on open air demolition).
- Specifying the methods for verification of completion of decommissioning, for example, the survey methods for residual contamination (e.g., Multi-Agency Radiation Survey and Site Investigation Manual [MARSSIM] survey and analysis).

Engineering/Design – For the activities listed below, design output documents can include: 1) engineering analyses, 2) design sketches, 3) drawings, 4) technical specification for procurement of equipment and material, 5) details for on-site fabrication of components and assemblies, and others. As discussed in Section 3.5, some engineering tasks are conducted after CD-3 in time for field implementation. The key point for such deferral is that the supported activities must be well understood to the extent that the engineering detail is not required for a reliable baseline.

The list below provides examples of engineering/design activities, and related deliverables for the preliminary design:

- Specifying "how" end points are to be achieved by identifying the locations of the isolation points and specifying methods to be addressed in design for physical modifications and installations. Examples of outputs include marked up location drawings and/or photographs, material specifications for flanges, plugs, and weld caps, gapping requirements, sequence instructions, inspection requirements, and others.
- Conduct safety analyses for design of new equipment/systems to support D&D, and for operations related to removal/decontamination of nuclear materials.
- Engineering and specifying flushing and decontamination of systems and surfaces, e.g., with isometric drawings showing flush paths and connection points, decontamination system performance requirements, and equipment specifications.
- Specifying application of fixatives including location identification, selection of types, coverage specifications, and inspection requirements.
- Engineering/designing shielding and other radiation control measures requiring physical installations (including material requirements and configurations).

- Engineering/designing structural reinforcements and modifications needed for worker protection, prevention of structural component failure, materials and package removal, dismantlement and demolition; these can require structural calculations and sketches or marked up drawings and/or photographs, sequence of steps, reinforcing specifications, and equipment specifications.
- Engineering/designing modifications and installations to support size reduction and waste management, which can include design for room reconfiguration, specification of size reduction equipment, layout of material flow paths, fixtures for staging, ventilation exhaust, pneumatic and electrical power sources, installation of detectors, and others.
- Engineering/designing modifications to the facility and systems and/or installation of temporary systems needed for electric power, breathing air, ventilation, water supplies, and water treatment. Design output documents should show physical configuration, specify components and materials, detail attachments and supports, etc., through use of flowsheets, process and instrument diagrams, piping and equipment arrangement drawings, electrical one-line diagrams, electrical termination and instrument loop schematics, and other documents as required.
- Decisions on the timing and significance of the level of detail for any of these (and other) examples are inherent to the project management process.

2.4 Final Design Phase, Approve Start of Construction (Ready for Implementation), CD-3

DOE O 413.3A Statements

The description for CD-3 in DOE O 413.3A is:

> "With design and engineering essentially complete, a final design review performed, all environmental and safety criteria met, and all security concerns addressed, the project is ready to begin construction, implementation, procurement, or fabrication. CD-3 provides authorization to complete all procurement and construction and/or implementation activities and initiate all acceptance and turnover activities. Approval of CD-3 authorizes the project to commit all the resources necessary, within the funds provided, to execute the project."

The specific DOE O 413.3A requirement is:

> "Complete and review Final Design or determine that the design is sufficiently mature to start procurement or construction."

Recommended Approach

CD-3 for a D&D project is appropriately called "Ready for Implementation." For final design, relatively little additional technical planning should be necessary as it should have been substantially completed at preliminary design to support baseline development. Additional planning will arise during conduct of the project as previously unknown conditions or unexpected situations become clear, and to support needed implementation decisions.

For the most part, final design includes completing the engineering/design output documents that were initiated during preliminary design. These may include:

- Design drawings and sketches.
- Specifications for equipment and materials.
- Analyses that will dictate the conduct of work or procurement of equipment.
- All other engineering efforts specific to the project needs (see examples in Volume II, Section 1).

D&D projects need considerable engineering effort to create one-time procedures and work packages to support operational type tasks as well as removal and demolition or closure. Project-specific procedures needed as soon as field work is initiated should be complete by CD-3. However, project-specific procedures for which the D&D work is far off in the project's schedule may be deferred. In general, detailed work packages are scheduled at a time prior to when they are needed.

2.5 CERCLA Engineering/Design Phases

Most decommissioning (not deactivation) projects within DOE-EM are conducted as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Non-Time-Critical Removal Action. Direct analogs between DOE 413.3A critical decisions and CERCLA stages include:

- Pre-Record of Decision (ROD) deliverables such as Remedial Investigation/Feasibility Study (RI/FS) and Engineering Evaluation/Cost Analysis (EE/CA) are equivalent to those leading to CD-1.
- Post-ROD Remedial Design/Remedial Action (RD/RA) Work Plan development activities can be equivalent to those leading to a CD-2 performance baseline.

The specific challenge is to align the sequences and schedules of CERCLA and DOE O 413.3A activities. That said, the intent here is not to duplicate efforts; as such, engineering/design results developed to satisfy CERCLA requirements can/should be used to meet the requirements of DOE O 413.3A and the intent of this guidance where equivalency in the level of detail and rigor can be shown.

Federal Facility Agreements, plus results of negotiations with the Environmental Protection Agency and stakeholders that address the overall site and area strategy are major factors in deciding the end state of facilities subject to CERCLA actions. Technical considerations resulting from strategic decisions can be drivers for project specific-functions and requirements; as such they must be integrated with project planning and engineering.

3. Guidance for Project Management Decisions

This section presents a decision framework for tailoring engineering/design activities to D&D projects; in particular to recognize that most field work and its related engineering does not follow the classic design-build type of schedule.

3.1 Project Management Responsibility for Establishing Priorities

The overriding principle for this guidance is that engineering/design must be conducted sufficiently early for a facility undergoing D&D to: 1) identify information needed for proceeding, 2) recognize technological challenges and initiate resolution, and 3) develop a high confidence scope, schedule, and cost baseline. Current perceptions may be that this is already the case; reviews of the conduct of EM projects indicate otherwise and that prior to major fieldwork, a greater fidelity of project definition is needed in order to reduce project/technical uncertainties and achieve excellence. The D&D engineering/design expectations described herein represent a departure from some past cases and aim to significantly improve the technical detail and documentation that provides the bases for the project baseline.

3.2 Considerations of Project Complexities

Within the framework of entire D&D project, with potentially hundreds of major tasks, some tasks may pose constraints and complexities that can delay the ability to provide detailed engineering/design results in a timely manner. Recognizing and adapting to such situations is the responsibility of the FPD and the IPT. Examples of complexities and constraints that can hinder completion of engineering/design include:

- Long-lead decisions – The existence of a particular waste stream (such as mercury) that has no disposition pathway, and for which proceeding with project planning and execution cannot await resolution of a long-lead decision for which engineering/design for dealing with the waste stream. Interim solutions may be needed in this case.
- Site wide interfaces – Utility services that must be reconfigured to serve facilities that will remain operational; or utility routing that controls the sequence in which facilities can be isolated (so that buildings needing services such as water and electricity are not prematurely cut off) are examples for which site-wide engineering and planning may be prerequisite for D&D planning of one or more of the facilities. If the site-wide schedule cannot accommodate individual facilities' project schedules, planning assumptions or engineering of interim solutions may be called for.
- Technology development – Adapting remote technology devices to a project-specific configuration, such as for disassembling/cutting reactor internals, or for placement of detectors and cameras are examples where designs may not be finalized and fabrication completed before it is necessary to start work to prepare for their installation.
- Access for characterization – A project that requires removing materials, equipment and/or building structure to gain access for collection of characterization information (e.g., the need to measure nuclear material holdup in equipment or systems) is an example where complete knowledge to plan the project cannot be obtained without first doing some work. Once access is gained and information collected, baseline assumptions and planning can be validated or modified. Engineering/design activities (e.g., structural reinforcement, systems isolation, temporary systems placement, or a demolition sequence) that depend on the information can then be completed.

For these and other such situations, when the need for results is considered "significant" to the baseline (per Section 4 of this guide), compensating for uncertainty is addressed with risk management and contingency determination. However, engineering/design should still be conducted to the degree feasible because partial results that accommodate a range of assumptions and/or partial solutions with interim measure. It is incumbent upon the FPD and the IPT to complete other significant engineering/design activities that do not have such constraints.

3.3 Sequence for Managing this Guidance for a D&D Project

Figure 2 shows the logical set of steps in applying this guide in a tailored manner. Each step is described in Table 1. The following is an overview discussion of the upper and lower portions of the figure. Section 4 and Volume II, Section 1 of this guidance document address the engineering/design aspects of these steps.

3.4 Possible Need for Substantial Up-Front Characterization or Technology Application

Decisions to identify the possible need for significant early expenditure for project definition are indicated in Steps 1 through 6 of Figure 2. An important aspect of project management responsibility is to recognize technical challenges requiring special attention and to be aware of uncertainties needing resolution to support detailed planning and engineering/design. This is especially the case for projects that are technically complex, first-of-a-kind, or one-of-a-kind. Projects with these types of technical challenges usually need either or both of two types of technical input, which are:

- Up-front characterization associated with assessing the physical condition of the facility and characterization of the facility's SSCs for residual radiological and/or chemical contamination. Characterization information is needed for purposes of worker safety, environmental protection, deciding on D&D methods, and waste management.
- Identifying and applying technologies to support D&D work. That is, adaptation of existing technology or the need for new technology for any of several reasons; for example: material stabilization and removal, SSC size reduction, remote and/or robotic operations, process design, characterization, and others.

Timing Issues – Considerable up-front characterization and technology application may be required before key decisions can be made regarding the best way to conduct the project. As a result, considerable expenditures for investigation and development can occur well in advance of the CD-1 and CD-2. In such cases, the budget authorization and timing of the project's critical decision should be tailored to the need for such development.

3.5 Relating Engineering/Design Activities/Deliverables to Project Phases

It is a key responsibility of project management to decide which engineering/design activities are critical to their projects because they have significant technological content and/or they represent a significant portion of the overall project scope. Steps 9 through 17 of Figure 2 are for distinguishing among engineering/design activities that must be substantially completed to support the project baseline, versus those that can occur at other times during conduct of a project.

The logic shown in the lower section of Figure 2 can be viewed as follows:

- Steps 10 through 13 indicate those activities that must be well developed for a baseline. Section 4 of this guidance provides a checklist and process for identifying those activities for which engineering/design detailed development is critical to support the baseline. In many D&D projects, these activities will be clearly recognizable because of the technical challenges to conducting work within the facility.
- Step 8 relates to combining critical decisions as part of overall project planning versus individual engineering/design activities (see Section 2).
- Steps 14 and 15 relates to many project activities for which engineering/design deliverables are provided well after project implementation has started but sufficiently in advance of their actual need. This is acceptable for activities that are well known and for which the ability to create a high confidence project baseline does not rely on their detail.

- Steps 16 and 17 relate to many facilities that continue to have operational requirements (e.g., to maintain safety) aside from those field activities directly associated with a D&D project. Those operations must continue regardless of CD approvals. Similarly, some D&D projects are funded for activities to be initiated in the field prior to completion of the CD process. These include activities that are necessary to define the project (such as characterization), conducted under operations budgets (such as removal of nuclear materials and flushing of systems containing hazardous chemicals), and those for which the scope, schedule, and cost are well understood (such as stand-alone equipment removal and permanent shutdown, road grading for heavy equipment access, isolation of a piping system).

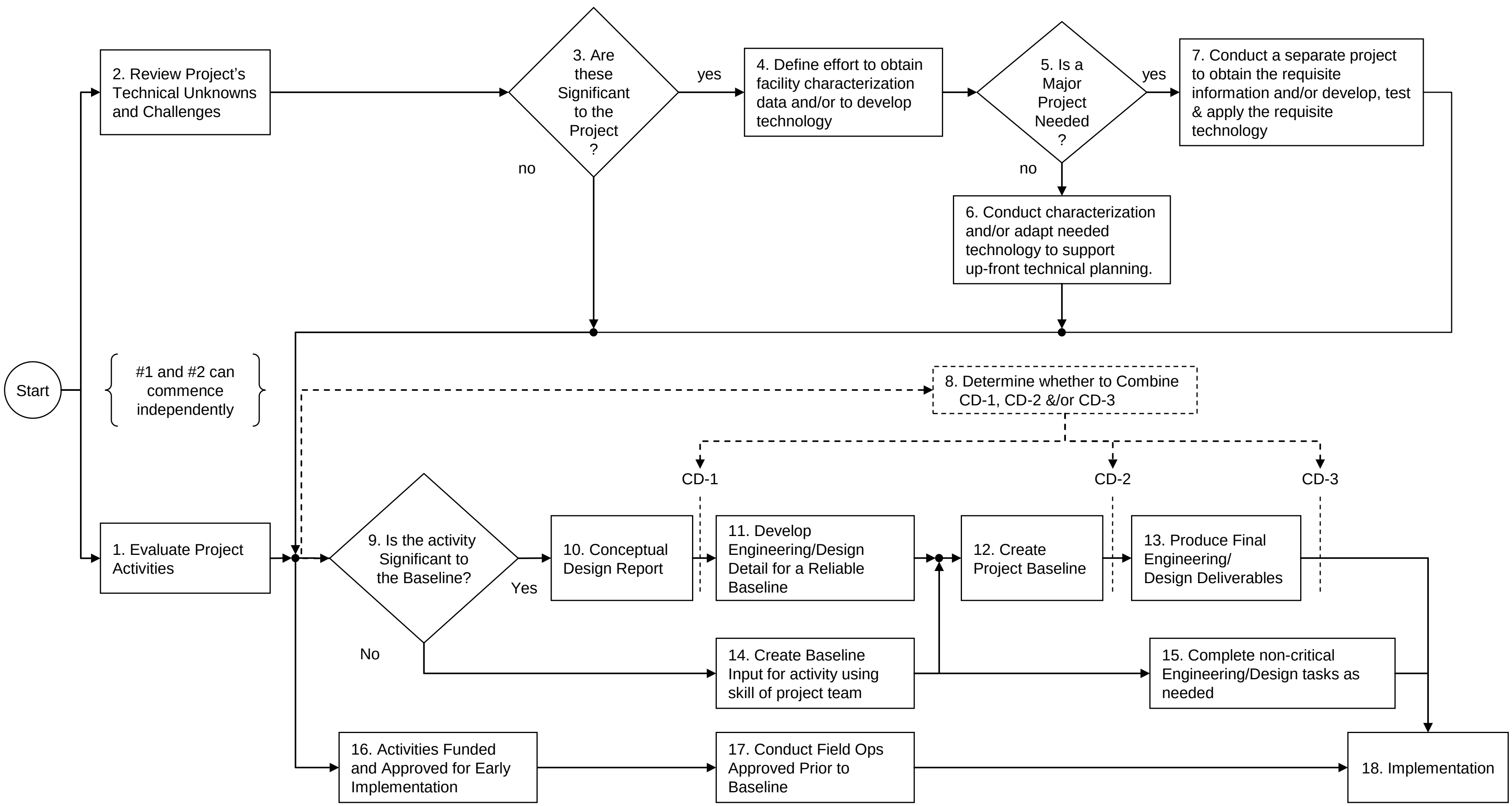

Figure 2 – Logic for Using this Guidance

Table 1 – Description of Project Logic Steps

No.	Title	Description	Text Location (sections)
1	Evaluate Project Activities	Goes hand in hand with setting up the project WBS. With regard to this guidance, the purpose is to identify project activities that need engineering/design skills for their conduct.	3.4, 4
2	Review Project's Technical Unknowns and Challenges	Goes hand in hand with early phases of project risk management. Evaluate uncertainties associated with the project with specific focus on: • adequacy of characterization of all SSCs for support of D&D operations of for waste management planning • potential for technology adaptation to address physical conditions that pose an unusual safety threat or will be costly to overcome in terms of personnel exposure or dollars	3.1, 3.4
3	Are These Significant to the Project?	Decide whether these facility and engineering/design uncertainties present significant risks (i.e. unacceptable level of uncertainty) to safety or to the project cost or schedule if they are not resolved prior to project initiation.	3.1, 3.4
4	Define effort to obtain facility characterization data and/or develop technology	Define the type and magnitude of effort required to address the outstanding issues that increase project uncertainty. Evaluate the scope, cost and schedule for the required activities. Consult other D&D programs and resources for solutions to similar challenges.	3.1, 3.4
5	Is a Major Project Needed?	Decide if resolving the issues contributing to uncertainty is of sufficient magnitude to delay proceeding with the Conceptual Design.	3.1, 3.4
6	Conduct characterization and/or adapt needed technology	Initiate tasks and/or small projects to resolve the uncertainties/reduce the project risk to acceptable levels. Overall project schedules may need to be revised to reflect these changes if they cannot be completed in parallel with other scheduled project tasks.	3.1, 3.4
7	Conduct Separate Project to obtain the requisite information or develop, test and apply technology	Conduct a major effort to resolve uncertainties, monitoring the progress of development to ensure that overall project needs are being met and appropriate alternative approaches are being considered where novel strategies are required.	3.1, 3.4
8	Determine whether to combine CD phases	Based on the complexity and expected duration of the project, the Integrated Project Team and Federal Project Director should determine whether it is appropriate to combine CD review phases and document expectations for those evaluations.	2
9	Is the activity significant to the baseline?	Decide which of the planned activities for which engineering/design deliverables are critical to developing a reliable baseline scope, cost, and schedule. These activities must be well advanced for BOE and baseline input and completed prior to project initiation.	4.1, Vol II, Sect.1

No.	Title	Description	Text Location (sections)
10	Conceptual Design Report	Identify alternatives and select preferred alternative with end points. Use the DOE M 413.3-1 Guidance for CDR content (Section 5.2.4). Develop ROM budget and schedule estimates for project.	2.2, 3.5
11	Develop Engineering/Design Detail	Produce engineering/design deliverables at a level of details sufficient for project scope, schedule and cost baseline definition.	2.3, 3.5
12	Create Project Baseline	Complete project BOE, cost estimate and develop project schedule.	2.3, 3.5
13	Produce Final Engineering/Design Deliverables	Complete engineering/design deliverables that were begun in Step 11.	2.4, 3.5
14	Create Baseline Input for activity using skill of project team	This represents routine engineering/design activities that represent common practice and can be developed later. The baseline input for the activity can be based on skill and judgment of the project's engineers, estimators, and schedulers, using standard estimating techniques.	3.5 Vol. II, Sect. 1
15	Complete non-critical Engineering/Design tasks as needed	Those activities identified in Step 14 can be completed at any time prior to the need for their implementation. This may be before CD-3, but in most cases will be later.	3.5 Vol. II, Sect. 1
16	Activities Funded and Approved for Early Implementation	This represents engineering support for: • Facilities that enter a D&D project with ongoing mission • For when it has been recognized that activities should start early because their results will be needed for the baseline (e.g., SSC characterization). • Activities are prerequisites to D&D (e.g., site preparation, access, staging areas). • Funds are available for obvious actions (e.g., cleanout of legacy waste, removal of recyclable materials). These items are funded outside of the baseline, or alternately should be included in the baseline from some stated initiation date.	3.4, 3.5
17	Conduct Field Ops Approved Prior to Baseline	Implement activities identified in Step 16.	3.4, 3.5
18	Implementation	Implement approved actions per project schedule.	Vol. II, Sect. 1

4. TAILORING AND REVIEW OF ENGINEERING/DESIGN ACTIVITIES

This section provides a process for selecting those D&D project activities for which high level of engineering/design detail is important to a well-defined project with a reliable baseline[12].

4.1 Examples of Project Activities with Engineering/Design Deliverables

To provide specificity for the principles put forth in Sections 1 through 3, a "catalog" of 48 typical D&D project activities is provided in Volume II, Section 1, all of which require engineering involvement. These are applicable to many D&D projects[13] in general; but not all apply to all projects. Which activities are suitable to a specific project depends on the attributes of the project.

The discussion of each of the 48 activities describes engineering/design deliverables corresponding to: a) concept development, b) support for the project baseline, and c) ready for implementation. It is important to keep clear the difference between engineering/design progress for *individual activities* and the overall engineering/design status for the *project*. Engineering detail/deliverables needed for the projects' conceptual or baseline development do not require the corresponding deliverables for all project activities; only for those activities judged to be "significant" to the project. When deemed as not significant, the baseline can be based on skill and judgment of the project's engineers, estimators, and schedulers; for example for cost estimating using rough-order-of-magnitude (ROM) methods.

Table 2 provides a checklist template for designating a project activity as significant; primarily from a baseline development perspective. (A simpler version of the table is shown with the project example in Volume II, Section 3.) The checkmarks in Table 2 indicate preliminary judgments of significance based on the individual descriptions in Volume II, Section 1. However, as illustrated in the hypothetical project in Volume II, Section 3, the activities of significance for any specific project will vary from those indicated in Table 2; the project team must make such decisions.

4.2 Evaluation Steps

The following three steps are suggested for identifying engineering/design deliverables needed to support the baseline. Volume II, Section 3 contains a fictitious example of a project to which these three steps have been applied as a test of its usability and a demonstration of how the method is used.

<u>Step 1: Identify Activities for Which Engineering/Design Deliverables are needed</u>

1.1 Identify project activities for which engineering/design deliverables are needed[14]. Sources include the project Work Breakdown Structure (WBS) and schedule.

1.2 Select those applicable to the project based on the descriptions in Volume II, Section 1.

1.3 Add as appropriate project activities not in Volume II, Section 1 that require technical deliverables.

1.4 Provide a greater level of detail for activities that are on the list but for which the description in Volume II, Section 1 is too general.

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[12] As discussed in Section 3.3, D&D baseline development must also consider engineering-dependent project activities that are not keyed to a CD-2 milestone. These include activities associated with operations, maintenance, characterization, technology application, and others that are in progress prior to CD-1/2. On the other end of the timeline, baseline development is without deliverables for engineering that is conducted after CD-3.

[13] Projects subject to DOE O 413.3A are those for which the total project cost exceeds $5 million.

[14] It is understood that there are more activities of significance to the project than only those requiring engineering/design detail. However, the scope of this guidance is limited to engineering/design.

<u>Step 2: Identify Activities for Which Engineering/Design Deliverables are Significant to the Baseline</u>

2.1 Create a table for the project using the template in Table 2.

2.2 Identify activities for which engineering/design is significant to the baseline using the following checklist:

- ☐ Based on knowledge of the project, experience, instinct and/or judgment
- ☐ Is indicated as significant in the descriptions in Volume II, Section 1
- ☐ Is indicated as significant in the activities identified by the project team
- ☐ Requires adaptation or development of technology
- ☐ Has some unique challenge that makes it a first-of-a-kind or one-of-a-kind effort compared with past experience
- ☐ Is operationally complex; for example, difficulty of access, extreme operating conditions (temperature, pressure, flow, chemistry)
- ☐ Is engineering/design-wise complex
- ☐ Requires detailed specifications for procurement of materials and/or equipment
- ☐ Has been identified as a significant project risk element
- ☐ Other reason ____

2.3 Using the checklist above for each activity and observing the example in Section II-3, provide an explanation in the second column as to why the activity is "significant"; meaning that substantial engineering/design is needed for the baseline development.

2.4 Then, check the third column of the project equivalent as appropriate in Table 2.

<u>Step 3: Record Results and Specify Deliverables</u>

3.1 Table 3 is a template for recording the results; it is based on the format used for individual activities in Volume II, Section 1.

3.2 Record details of the selected activity in the Table 3 template.

3.3 Specify the deliverables that must be completed for each project phase in the Table 3 template.

4.3 Use of Evaluation Results

It is left to each project team to determine how and if they want to incorporate this approach in their own methods. Regardless of the process used, providing the indicated information will result in more substantive reviews by others not directly involved in the project. The results of the steps described above can be used within the project for creating the specified deliverables and their use to support:

- Technical planning; including feasibility determination, and conceptual design development.
- The basis of estimate and the technical baseline.
- Risk assessment; one of the inputs to the identification of project technical challenges should be the results of the risk assessment.
- Field work; technical requirements for operations, construction, decontamination, demolition, and development of related procedures.
- Procurement; functional and technical details for specifications for solicitation, contracts, and purchases.

Table 2 – Deciding which Project Activities Require Early Engineering/Design (Shading is for reading convenience.)		
Type of Activity	**Bases for Significance or Not**	**Significant**
1. Alternatives Analyses and Selection		
2. Deactivation End State and End Points		
3. Post-D&D Surveillance & Maintenance		
4. Process System Deactivation and Isolation		
5. End Points for Operable and Mothballed Systems and Equipment		
6. Nuclear Safety Analyses		
7. Facility Condition Assessment		
8. Characterization of SSCs and Process Materials Likely to be Disposed as Waste		
9. Characterization for Compliance		
10. Equipment Dismantlement and Removal		
11. Size Reduction		
12. Liquid Flush and Drain		
13. Surface Decontamination		
14. Fixative Application		
15. Mockups		
16. Technology Application		
17. Shielding Design		
18. Building Structural Integrity		
19. Temporary Electrical Service		
20. Replacement Electrical		
21. Ventilation Modifications		
22. Temporary Ventilation		
23. Breathing Air		
24. Temporary Enclosures and Containments		
25. Hazards Analysis		
26. Hazardous Material Abatement		
27. Liquid Waste Management		
28. Waste Identification & Planning		
29. Waste Conditioning & Packaging		
30. Waste Staging		
31. Waste Transport & Disposal		
32. Facility Isolation		

Table 2 – Deciding which Project Activities Require Early Engineering/Design (Shading is for reading convenience.)		
Type of Activity	**Bases for Significance or Not**	**Significant**
33. Temporary Roads and Access Ways for Heavy D&D Equipment		
34. Temporary Water for D&D		
35. Completion Verification Survey		
36. Demolition Method and Sequence		
37. Environmental Requirements and Controls for Open Air Demolition		
38. Site/Civil Work During and After Final Disposition		
39. Closure Configuration		
40. Decommissioning End State and End Points		
41. Operations and Maintenance Reduction		
42. Radiological Engineering		
43. Trade-off Studies		
44. Reconfigure Security Boundary		
45. Waste Treatment		
46. In-Situ Decommissioning Grouting/Void Fill Analysis		
47. In-Situ Decommissioning Cover Systems		
48. Authorization Basis Step-Out Criteria		

Table 3 – Recording a Significant Activity (See Section II-1 for examples)
Activity Title and Description
Engineering/Design Indicators of Significance – Briefly describe the reason that engineering/design detail is or is not needed for the baseline. (second column of Table 2)
Concept Development for Key Engineering/Design Deliverables (CD-1) – Identify key, specific engineering/design deliverables (functional requirements, analyses, evaluations, concept drawings, walkdown/survey reports, others)
Development of Baseline for Key Engineering/Design Deliverables (CD-2) – Identify key, specific engineering/design deliverables (performance requirements, drawings, calculations, equipment lists, equipment specifications, sequencing requirements, others)
Ready for Implementation for Key Engineering/Design Deliverables (CD-3) – It is assumed that deliverables identified above will be developed in further detail. If there are key deliverables not previously identified, describe them here.

5. Lines-of-Inquiry for Independent Review

5.1 Perspectives for Reviewers

The purpose of this section is to provide independent reviewers with example lines-of-inquiry (LOI) related to D&D project engineering/design activities and deliverables.

Independent reviewers should become familiar with the logic in Figure 2 to gain an understanding when inquiring about engineering/design tasks needed prior to CD-1. As a first step, the following questions should be discussed with regard to the overall project:

- Is characterization sufficient to support detailed planning? Is a major characterization sub-project needed?
- Is a major technology sub-project needed?

The results of such discussions will provide insights into whether or not these two potential issues will require significant expenditure to obtain information and technical detail before the baseline can be fully assembled; or whether either is recognized as a high risk, with contingency assigned to acknowledge the uncertainty.

Understanding the principles in Sections 1 through 3, and the process in Section 4 (along with the example in Volume II, Section 3) should provide insights for inquiry regarding engineering/design results and deliverables for the project's significant activities.

Reviewers should also gain an understanding of the timing of the project's planning discussed in Section 3. For many activities a high degree of certainty for the baseline does not require complete engineering details; their scope, schedule, and cost can be based on skill, experience, and judgment of the project's engineers, estimators, and schedulers. These activities include continuing operations and maintenance, plus those for which engineering/design is to be conducted after CD-3 and prior to their implementation.

5.2 Example LOI

As a starting point for reviewers, Volume II, Section 2 lists example LOI for: a) the process steps for deciding which activities are important to the baseline, and b) engineering/design expectations for the activities in Volume II, Section 1. The descriptions of each activity in Volume II, Section 1 can aid reviewers in developing their own LOI.

In practice, engineering/design LOI should be developed to focus on those activities deemed "significant," have a high degree of uncertainty, or are needed early in the project. Table 2 and the "Indicators of Significance" for each of the activities in Volume II, Section 1 can be used by reviewers for insights into systematically identifying key projects. In addition, for project activities that are not significant, the LOI in Volume II, Section2 can be used as a starting point for reviews of engineering/design activities at the time they are needed.

Volume II, Section 2 focuses the LOI on the recommended/appropriate level of technical detail development at CD-1 and CD-2. LOI for CD-3 is not addressed separately because it is expected that engineering/ design for CD-3 is the continuation and completion of that initiated for CD-1 and developed for CD-2.

Note that a generic line-of-inquiry at CD-2 for all activities is: "Have the results of engineering, design, and analysis been incorporated in the Basis of Estimate, as well as in the scope, schedule, and cost baseline?" Since this applies to all activities, it has not been repeated for each in Volume II.

6. DEFINITIONS AND ACRONYMS

6.1 Definitions of Action Verbs Specific to this Guidance

To avoid confusion regarding specific action verbs used in this guidance, the following meanings are stated. The intent here is not to create inflexible "definitions," but rather to differentiate among terms that in other instances may be used with less specificity. Their use is most important in Sections 2.2, 2.3, 2.4 and in Volume II, Section 1 where they convey and differentiate between the expected levels of detail associated with engineering/design activities.

Verb	As used in this Guidance
Analyze	Conduct an engineering analysis using calculations, evaluation of data, and/or review of inspection results to arrive at a conclusion and to provide recommendations for a course of action, design, procedures, and other technical requirements.
Create	Includes technical planning, engineering, and design activities to produce an engineering or design product.
Describe	Record in a project document what has already been decided, selected, specified, or designed.
Design	"Design" creates documents to support field work. For D&D, design should be taken in a broader context than typically what would otherwise be mostly drawings, specifications, and other design output documents for a design-build project.
Evaluate	Conduct and document engineering investigation of options to arrive at the performance requirements, design features, SSCs selections, and other project requirements. Reviews, which are more abbreviated in the above description, are nevertheless encompassed by "evaluate."
Engineer	Apply engineering skills and disciplines to create products of design such as specifications, drawings, installation and fabrication instructions, etc. and other technical documents such as plans, operational procedures, and evaluations.
Identify	Conduct and document the results of document reviews, facility walkdowns, operations and maintenance staff interviews, and other actions for purposes of design development, installation, removal, operations, maintenance, and other tasks.
Plan	Produce a plan that can address actions ranging from broad facility and campaign (e.g., waste campaign) strategies to individual procedural requirements for specific field work.
Specify	Formally state and document detailed technical requirements such as materials, size, fabrication methods, field methods, and other requirements for procurement, installation, establishing conditions, conducting field work, and typical project activities.

6.2 D&D Specific Definitions

Use of "D&D"

"D&D" is used as a general acronym for which it is unnecessary to explicitly define each "D." In the context of the project management order, and in this guidance, deactivation and decommissioning are the primary foci because each can be a separate project or can be a phase of a combined project. The following are formal definitions of these two D's plus decontamination and demolition. Additional notes are provided regarding the usage of deactivation and demolition.

For purpose of this guidance, it should be clearly understood that regardless of the use of these terms ("deactivation," "decontamination," "demolition," "decommissioning") to characterize specific projects, the requirement for preparing engineering/design specifications consistent with the guidance provided remains applicable.

Deactivation

Source: DOE O 430.1B – Placing a facility in a stable and known condition including the removal of hazardous and radioactive materials to ensure adequate protection of workers, public health and safety, and the environment, thereby limiting the long-term cost of surveillance and maintenance. Actions include the removal of fuel, draining and/or de-energizing nonessential systems, removal of stored radioactive and hazardous materials, and related actions. Deactivation does not include all decontamination necessary for the dismantlement and demolition phase of decommissioning (e.g., removal of contamination remaining in the fixed structures and equipment after deactivation).

Note Regarding Deactivation

For a variety of reasons, the scope of deactivation beyond the above description varies among sites as well as facilities. For example:

- At Savannah River, deactivation for some facilities refers to complete cleanout and decontamination such that demolition can proceed as an industrial facility.
- At Hanford, and Savannah River, deactivation is commonly used to describe the work associated with removal of equipment for the purpose of hazard mitigation and other preparatory operations such as utility isolation. The end state is a facility that is "inactive" or "shut down."

Decommissioning

Source: DOE O 430.1B – The process of closing and securing a nuclear facility or nuclear materials storage facility to provide adequate protection from radiation exposure and to isolate radioactive contamination from the human environment. It takes place after deactivation and includes surveillance, maintenance, decontamination, [demolition, entombment (in-situ decommissioning),] and/or dismantlement. These actions are taken at the end of the life of a facility to retire it from service with adequate regard for the health and safety of workers and the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or restricted use of the site.

Decontamination

Source: DOE O 430.1B – The removal or reduction of residual chemical, biological, or radiological contaminant and hazardous materials by mechanical, chemical or other techniques to achieve a stated objective or end condition. *[Clarification: This is a universal action and may be conducted, to some extent, during any phase of facility disposition.]*

Demolition

Source: ANSI A10.6; Safety Requirements for Demolition Operations – The dismantling, razing, or wrecking of any fixed building or structure or any part thereof. *[Clarification: See also 10 CFR 1926, Subpart T, Demolition.]*

Note regarding Demolition

Beyond the action of bringing down a structure, "Demolition" is often used to characterize a decommissioning project phase for which achieving a demolished end state is the primary objective. However, from an overall project perspective, many activities occur before the actual demolition to prepare the facility (e.g., asbestos abatement), and many activities occur afterwards to achieve the final specified conditions for the site.

6.3 Acronyms

Acronym	Definition
A/B	Authorization Basis
ALARA	As Low as Reasonably Achievable
BOE	Basis of Estimate
CD	Critical Decision
CDR	Conceptual Design Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
D&D	Deactivation and Decommissioning
DOE EM	Department of Energy Office of Environmental Management
DQO	Data Quality Objectives
EE/CA	Engineering Evaluation/Cost Analysis
HEPA	High Efficiency Particulate Air
IPT	Integrated Project Team
ISOCS	In-Situ Object Counting System
ISD	In-Situ Decommissioning
LOI	Lines-of-Inquiry
LOTO	Lockout-Tagout
LTS	Long-Term Stewardship
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
NCSE	Nuclear Criticality Safety Evaluation
NDA	Nondestructive Assay
O&M	Operations and Maintenance
PBS	Project Baseline Summary
RCRA	Resource Conservation and Recovery Act
REVCOM	Review and Comment
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROM	Rough Order of Magnitude
S&M	Surveillance and Maintenance
SSC	Systems, Structures, and Components
SWB	Standard Waste Box
TRU	Transuranic Waste
USQ	Unreviewed Safety Question
WAC	Waste Acceptance Criteria
WBS	Work Breakdown Structure

Tailoring Deactivation & Decommissioning Engineering/Design Activities to the Requirements of DOE Order 413.3A

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II - 1. D&D PROJECT ACTIVITIES REQUIRING ENGINEERING/DESIGN

In this Section, each of the 48 typical D&D engineering/design activities is described with information as follows:

- Purpose and Description – The descriptions here are at a fairly high level as they might be listed in a project WBS dictionary. For baseline cost estimate and schedule creation, each would need to be broken down into its respective subset of activities.
- Engineering/Design Indicators of Significance – The intent of these indicators is to help project teams and independent reviewers identify for a specific activity those project-significant activities for which engineering/design must be developed in greater detail for a reliable project baseline. It is important to identify these critical engineering/design activities early and focus the appropriate level of resources on them.

For other activities, the BOE and the baseline can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

- Concept Development – In the concept development phase of each activity, the engineering/ design development focuses on detailed functional requirements of *what* needs to be done for the activity.
- Development of Baseline – During this phase, the engineering/design advances to the additional technical detail needed to support the project baseline. Development focuses on *how* the activity is to be implemented, during which engineering/design deliverables for the activity should be well advanced.
- Ready for Implementation – represents completion of deliverables to the point needed to support conduct of the activity in the field.

In addition to baseline development, output from these activities provides input to procurement, quality assurance, health and safety planning, integrated safety management, work packages and procedures, training, and other functions for project implementation.

The numbering and order of activity listing does not imply priority or operational sequence. It should be understood that any specific project will not require all the activities in this table; and undoubtedly, some projects will have activities that are not listed. It is the responsibility of project management to address which apply and their importance, as discussed further under the tailoring discussion in Section 3.5 and the process in Section 4.

Activity #1 Alternatives Analyses and Selection

The purpose of this activity is:

- For decommissioning, to identify and select an approach and the decommissioning end state.
- For deactivation, to decide the degree to which the facility will become be shutdown and non-operable.
- For deactivation, to decide if the deactivation effort will reduce the facility hazard category.

Description

This activity is to define, evaluate, and select alternatives for the end-state conditions of a facility or group of facilities to be decommissioned. For CERCLA projects, these engineering activities are conducted to support the Remedial Investigation/Feasibility Study (RI/FS) or Engineering Evaluation/Cost Analysis (EE/CA). Evaluation can also address facility category reduction; say from Nuclear Category 3 to a Radiological or Industrial Category to determine if efficiency of conducting deactivation activities will be improved.

A defensible method of evaluating each alternative must be used. Typically, this requires the selection of objective criteria (e.g., cost, effectiveness, regulator acceptance, ease of implementation, etc.) against which each alternative is evaluated. A variety of evaluations may be used. One is called “structured value analysis” in which weights are assigned to each criterion based on importance to success of the project; each alternative is graded for each criterion, and the alternative compared based on the weighted results among them. Other evaluation methods can involve a more explicit comparison using CERCLA criteria of effectiveness, implementability, and cost.

Engineering/Design Indicators of Significance

Alternatives analysis is likely to be a significant engineering/design element of baseline development because the selected alternative establishes the bases for project scope.

Concept Development

A set of alternatives to accomplish the end state vision for the facility should be identified. While the range of alternatives should include all reasonable and promising choices available to decision makers, it is normally desirable to keep the number of alternatives considered in alternatives analysis as small as possible.

Conceptual alternatives are defined only to the level of detail necessary to explore the potential merits of the alternatives in addressing the problems in the facility. They are defined to the level of detail necessary to support a sufficiently reliable analysis of costs and impacts with the goal of identifying the optimum alternative for advancement to more detailed planning in the next project phase.

For a project subject to CERCLA the EE/CA and Action Memorandum, or RI/FS and Record of Decision (ROD), provide the selected alternative that becomes the overall technical approach for the Conceptual Design Report (CDR). For non-CERCLA projects, creating the CDR requires developing the project’s overall technical approach.

Several individual evaluations may be conducted to arrive at technical approach decisions for specific field activities. Recommendations from the evaluations define the concept.

Development of Baseline

Evaluation results are used to decide how to proceed with the project and also to provide input for further development of activities for baselining. However, creating the details for the selected alternative is provided in the conduct of other activities.

For a CERCLA project, the activities conducted to create the Remedial Design/Remedial Action (RD/RA) document plus other engineering/design activities provide input to the project baseline. For non-CERCLA projects, engineering/design equivalent to that needed for an RD/RA should be conducted.

Ready for Implementation

Preparation for implementation is not applicable because the results here are provided to other activities.

Activity #2 Deactivation End State and End Points

Purpose

This activity specifies the facility conditions to be achieved upon completion of a deactivation project; these conditions include:

- End state, which is a vision of the overall facility status.
- End points, which are the detailed conditions to be achieved upon completion.

Description

A deactivation project for a facility that is radiologically or chemically contaminated, or contains nuclear materials or bulk chemicals should apply the end points process to define project completion, regardless of degree of the contamination or amount of materials. This activity implements guidance provided in DOE G 430.1-3, *Deactivation Implementation Guide*[1].

Defining the facility end state establishes the high level requirements for conditions to be achieved at completion of a project. The end state should also address the facility disposition following project completion; for example extended surveillance and maintenance (S&M) and/or transfer to another organization.

The deactivation end state represents the agreed-upon facility condition that is to be achieved after completion of the deactivation effort. This condition is the ultimate goal of deactivation and is characterized by a safe facility configuration that can be maintained until decommissioning is feasible. The deactivation end state vision must be determined by the project team based on the project objectives, funding and schedule. For example, the deactivation end state vision for a particular facility could be defined as a facility from which all process equipment has been removed and all remaining surfaces decontaminated to unconditional release levels. On the other hand, it may be appropriate to define the deactivation end state as a facility from which all process equipment remains in the facility but has been cleaned of held up process materials and is mechanically and electrically isolated (e.g., via air gapping of pipes and conduits).

Specification of detailed space-by-space and system-by-system end point conditions to be achieved provides the requirements for the engineering/design and other work planning activities needed to develop the project performance baseline. Typically, it is the function of facility engineers to derive and specify end points applicable to the entire facility, which for large facilities can result in several hundred individual end points.

The detailed specifications for, and the actual end points achieved, will vary from facility to facility. Variations are expected because of the differences among facilities with respect to previous mission requirements, equipment and systems, containment, degree of contamination, ability to isolate the contamination, facility environs, projected ultimate disposition, and a host of other factors. Regardless, the methods used to decide and specify end points are fundamentally similar.

The number of specific deactivation end points will be directly related to the facility complexity and the scope of the deactivation project. The effort needed is dependent upon size, number of process systems and amount of equipment, number of rooms, connection to other facilities, and others. The number of end point specifications can range from less than 100 for a small facility with few systems, to several hundred (or more) for a large process facility such as a canyon or reactor. In contrast, for a deactivation project in which the scope of the project is complete cleanout of the facility, there will be very few end points.

[1] The Deactivation Guide provides additional detail on how to plan and implement the end points process.

Engineering/Design Indicators of Significance

Specifying end points is a significant engineering/design element for every deactivation project because they ensure the conditions to be achieved at the completion of the project are explicitly stated and understood.

Concept Development

The end state vision and functional end points should be established as a key input to the CDR. At the concept stage, the end point specifications are functional in nature. The degree of detail should address "what" the end points should be, but not "how" to implement them. For example, systems can be specified as continued operable, isolated and abandoned in place, or mothballed. Spaces (rooms, outbuildings, etc.) can be specified as access required or not during post-deactivation surveillance and maintenance.

A comprehensive *End Points Report* should be created that:

- Describes the overall end state of the facilities and area within scope.
- Describes the surveillance and maintenance *concept* that will be in place when the end state is achieved because it is a driver for developing end points (see Activity #3).
- Identifies each space in the main facility, all systems, and external structures within scope.
- States the criteria for end points.
- Specifies the conditions to be achieved for spaces, systems, major equipments, and external structures to meet the criteria.

Development of Baseline

For baseline development, engineering/design translates the conceptual (functionally defined) end points into "how" they are to be implemented. Baseline development includes:

- For each facility system and major equipment that is to remain operable or mothballed for future use:
  - If end points involve a change in physical configuration, a design change package should be engineered that includes marked up drawings, specification of components and materials, fabrication details, and installation requirements. An example of reconfiguration might be cascading a ventilation system in a large facility to fewer stacks; Activity #21, Ventilation Modifications would apply. See Activity #5.
  - If end points involve a change in operation mode, with or without physical changes, the new modes should be described so that the baseline can include the schedule and an estimate of the testing and operations to validate the new mode. Changes to the operations procedures and other documents may be deferred to the implementation stage. An example of operational mode change would be running a ventilation system in exhaust mode at a lower flow rate with the supply fans not operating; Activity #21, Ventilation Modifications would apply. See Activity #5.
  - If there is no substantial change in physical configuration or operation mode, no further detail is needed.
- For each facility system and major equipment that is to be permanently isolated, either of two cases might apply:
  - There is a standard procedure; it is sufficient to state the procedure. For example, if the electrical feed to a building is to be gapped, and a procedure exists for electrical gapping, it is

sufficient to refer to the procedure and rely on experience and judgment for the baseline activity.

  - There is no standard procedure; installation requirements for the isolation method must be designed and specified for each location and can include engineering/design sketches, drawings, marked up photographs, and specification of components and materials for isolation devices. See Activities #4 and #32.

- For the facility interior spaces and rooms, and exterior buildings and structures:
  - For which access will be required for periodic S&M, describe modifications or additions, if any, to ensure safety of personnel considering the changed mode of the facility in its deactivated state.
  - For which routine access will not be required, describe modifications or additions, if any, to prevent inadvertent entry.

Field investigation will be needed prior to CD-1 to provide information to develop the designs and specifications.

Ready for Implementation

Implementation of end points requires completion of design change packages and the development of detailed work packages and/or procedures. For end points that are complex or require long lead time, these activities should be substantially completed by CD-3. However, for end points that are relative straightforward to implement, work package and procedure development may occur after CD-3 with sufficient lead time for implementation.

Activity #3 Post-D&D Surveillance & Maintenance

For *deactivation* projects the purpose of this activity is to:

- Layout the details of the deactivation activities for cases in which deactivation is to be followed by an extended S&M period.
- Provide input to deactivation end points for which conditions are to be established to support post-deactivation S&M.

For *decommissioning* projects the purpose of this activity is to provide input for establishing physical conditions for activities that will be conducted after decommissioning is completed. This provides input to Long-Term Stewardship (LTS), where applicable.

Description

For *deactivation* projects this activity evaluates the S&M to be conducted after project completion. Depending on the scope of deactivation, evaluating the S&M needs can include identifying:

- Walk-through paths.
- Health and safety requirements for entry.
- Inspections for water in-leakage, animal intrusion, degraded structural conditions, hazards to workers conducting S&M, and other physical conditions of the building.
- Monitoring and maintaining equipment and systems that remain operational.

This activity applies to deactivation projects that place a facility in a monitored storage mode and for which an extended period of surveillance and maintenance is anticipated. For deactivation that is directly followed by demolition, S&M input to deactivation planning becomes moot.

The reason this planning is needed relatively early is because it provides input to the end-point conditions of systems and spaces within the facility. The procedures for implementing the S&M plan may not be needed until deactivation is complete; that is, prior to CD-4.

The S&M program should attempt to minimize the need for entry. Material security and safeguards may be another consideration. Facilities that house high-value or classified material will require safeguards and security measures. Situations requiring such measures should be reviewed with the goal of removing or otherwise eliminating the causative factors. Another primary area of concern is roof integrity, an essential element of maintaining the safety perimeter of the facility. Periodic attention to the condition of the roofing and possible repair may be necessary. It should be noted that events involving facility roofs (e.g., personnel falling through or water damage to equipment) have occurred periodically across the DOE complex, but may have been preventable with adequate inspection and evaluation.

For *decommissioning* projects, this activity requires understanding what the end state and follow-on activities will be (see Activity # 40). In a case of a green field end state, there may be no subsequent surveillance. In a case of Office of Legacy Management responsibility or institutional control of the site by the DOE, there may be monitoring requirements (or a decision that there are none) that could affect an interim or final configuration per the CERCLA Record of Decision.

Engineering/Design Indicators of Significance

Post-D&D surveillance & maintenance is not likely to require detailed engineering/design deliverables for the baseline because only the functional level of S&M planning is needed for input to end points planning prior to CD-3.

Detailed S&M procedures need to be developed prior to CD-4.

Concept Development

The deliverable for concept development should be a high level plan that addresses the points in the above description of this activity. Again, the purpose of this plan is to support end points development.

Development of Baseline

To produce the baseline, the work to develop the post-deactivation S&M procedures must be incorporated in the project baseline. This may be a specific activity for a large-complex facility; otherwise the effort can be encompassed within level-of-effort engineering support for the project.

Ready for Implementation

Beyond baseline development, there is no need for further development at CD-3. An S&M program must be functioning at the completion of the project. Therefore, development of a detailed plan and implementing procedures must be complete prior to CD-4.

Activity #4 Process System Deactivation and Isolation

This activity establishes the configuration for systems and equipment to be permanently shut down.

Description

Process system deactivation is accomplished by shutting down, isolating, and establishing individual components and/or a total system in a safe configuration. This activity refers to systems within the facility such as for ion exchange, evaporation, incineration, waste compaction, and glovebox lines for a variety of processes. It also includes process support systems such as ventilation, sumps and drain collection, and cooling water. Utilities and systems that originate or terminate external to the facility are addressed in Activity #33, Building Isolation.

Reasons for permanent shutdown of process components/systems include:

- Reducing or eliminating the need for facility-specific knowledge of how to operate non-conventional equipment and processes.
- Safety of D&D workers by reducing operating equipment, eliminating energetic sources (e.g., voltage, pressure, coiled springs), and reducing potential exposure to hazardous chemicals and radioactive sources.
- Reducing the overall operations and maintenance (O&M) resources needed.

Engineering/Design Indicators of Significance

Shutting down and isolating process systems is likely to be a significant engineering/design element of the project when there are more than two or three such systems.

Concept Development

Systems and major equipment to be shut down may be identified in Activity #2, End Points, during deactivation planning; or otherwise may be a condition of facility transfer from an operations organization to a D&D organization.

Definition of the conditions to be achieved should specify if the equipment /systems are to be abandoned-in-place or removed, either partially (components) or in total.

The timing for when operational, engineering, and design details are needed is dependent on the overall project plan. Reducing worker safety risk and eliminating the need for special operations knowledge will most likely be an early project requirement, in which case technical detail should be available for the baseline. Alternately, engineering activities to deactivate systems for purposes of reduced O&M burden may occur after CD-3.

Development of Baseline

Baseline development includes:

- Engineering to address operations that need to be conducted prior to shutdown and isolation. Deliverables include:
    - Listings of special nuclear materials and other nuclear sources to be removed and specifying requirements for their disposition.
    - Listings of classified equipment that must be removed.
    - Detailed plans for the conduct of flushing/draining (see Activity #12, Liquid Flush and Drain) and purging/venting.
- Engineering for isolation of the system/equipment. Deliverables include:

- New or marked up drawings to identify process inputs and outputs and isolation points for the system/equipment to be isolated.
- Isolation point tabulations, marked up drawings, sketches and photographs to aid in documentation.
- Isolation methods such as gapping of pipes and electrical conductors, blind flanging, permanent rack-out and removal of circuit breakers and motor control centers, and others (see the description of air gapping in Activity #32).
- Specifications for any special mechanical and electrical components needed for final isolation, including material standards and dimensions/sizes.
- Closure requirements such as gasketing, torque, verification inspection and testing.
- Requirements for the to-be-as-left configuration of the system/equipment after isolation, including final valve and switch lineups within the system and from/to connecting system.
- Engineering for removal (see Activity #10 regarding rigging)
- Identifying document change requirements, such as to the Authorization Basis, O&M procedures, and facility/systems configuration documents. While this task will not significantly affect the baseline, these changes should nevertheless be documented as a product of the engineering effort.

Ready for Implementation

Provide:

- Technical requirement inputs for isolation and verification procedures and work packages.
- Procurement specifications for materials, equipment, and services.

Activity #5 End Points for Operable and Mothballed Systems and Equipment

This activity establishes the configuration and modes of operation for equipment/systems that will remain operable or be preserved for future use.

Description

One type of end point specifies equipment and systems that remain operable following deactivation. A second type is for equipment and systems preserved for future use (i.e., "mothballed").

Continued operation or laying up equipment and systems for deactivation can involve considerable engineering if configurations and/or operating modes are to be modified in comparison with those during the prior period of mission operations.

An example regarding equipment to remain operable relates to fire protection. A decision as to whether fire suppression and/or detection remain active is closely linked with heating needs to prevent wet pipe systems from freezing, which in turn relates to steam and electrical systems. Ongoing maintenance must also be addressed. To address such a situation, a fire protection engineer must review the planned deactivated status of the facility (fuels, ignition sources, occupancy) and develop recommendations accordingly.

Similar considerations can be given to sump pumping and waste processing equipment and systems.

In practice, mothballing equipment for anticipated future use has been very limited. The most common example is for building cranes. Installed cranes can be of value during future activities that remove building components, position decontamination and segmentation equipment, and handle waste products. Depending on age and condition, decisions are needed as to whether cranes should be operated and maintained or preserved for future use following deactivation.

Engineering/Design Indicators of Significance

Implementing end points for operable and mothballed systems and equipment is not likely to require detailed engineering/design deliverables for the baseline because operation of these systems is well understood.

Exceptions include cases where there are many utility and service systems that will need to be reconfigured or have their operating modes changed (e.g., exhaust ventilation that must maintain sub-atmospheric building pressure for the near future).

Concept Development

Reviews by facility engineers are needed during end points development to decide what equipment to keep operational or to mothball. The conclusions are incorporated in the end points plan addressed in Activity #2. However, engineering is different from Activity #2 because of the different nature of the work (shutdown vs. operable end points).

Development of Baseline

For equipment and systems that remain operable, or require reconfiguration, or for which the operating mode will be changed, engineering/design deliverables include revised drawings, system design document (SDD), and technical requirements to be incorporated in revised operating procedures. Similarly, technical requirements should be provided for revised maintenance procedures and schedules. Where reconfiguration or operating mode changes are needed, operation analyses should be conducted in support of the change(s). The baseline should include an operations and maintenance (O&M) estimate.

For equipment that is to be mothballed, the preservation requirements must be specified.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Engineering/design activities that were initiated to support baseline development are completed.

Activity #6 Nuclear Safety Analysis

This activity evaluates:

- Activities involving nuclear materials and safety-related SSCs.
- Reducing the facility hazard category after hazard removal.
- Resources needed to support nuclear safety of D&D activities.

Description

The difficulty of performing D&D in Nuclear Facilities (Hazard Category 3 or higher) is increased due to the requirement to evaluate all proposed activities against the facility authorization basis. For example, in some cases key safety related systems, such as the ventilation system may need to remain active during initial D&D, until the nuclear material inventory is reduced to the point where the safety controls can be eliminated.

It may be advantageous to plan to remove the nuclear material inventory from the facility early in the project so the facility hazard category can be reduced below Hazard Category 3, thus eliminating nuclear safety controls. It has been found in some cases, however, that conducting D&D in a facility with hazard categorized as Radiological may not hold significant advantage compared with Hazard Category 3 status; in such cases it may be cost effective to reduce to Hazard Category 3, but not to a Radiological or an Industrial category.

This activity is related to, and often conducted in, support of Activity #48, Authorization Basis Step-Out Criteria.

DOE-STD-1189, *Integration of Safety into the Design Process*, provides guidance for the nuclear safety design.

Engineering/Design Indicators of Significance

Nuclear safety analysis is likely to be a significant engineering/design element of a project when the facility hazard category is Hazard Category-2 or Hazard Category-3. (Note: a Hazard Category-1 facility would not be in a D&D mode; also, it is unlikely for Category-2 facilities.)

Concept Development

At the concept development stage, it is appropriate to identify if nuclear safety is or is not an issue for the project, or at what specific locations within the facility the presence of nuclear material will constrain D&D activities. This is accomplished by a review of the existing Authorization Basis (A/B), inventory reports, mass balances, and process knowledge to determine where SNM is located within systems and equipment within the facility.

Development of Baseline

For projects where it is desirable to enact an A/B downgrade, the baseline should include:

- Planning for downgrading the facility and changing the A/B, including identification of facility systems covered in the facility authorization basis and A/B changes required to support D&D activities.
- Analyzing for inventory holdup, criticality modeling, and accident analyses for completion of a Documented Safety Analysis in accordance with 10 CFR 830.
- Evaluating characterization results (e.g., databases, tabulations, inventory reports) of the quantities of residual SNM including the type of SNM involved, isotopes of concern, type and number of equipment and locations where holdup is likely. This information is used to estimate the number of nuclear criticality safety evaluations (NCSEs) and unreviewed safety questions

(USQs) that are required to support D&D activities. (As noted later, task based NCSEs and USQ evaluations to support D&D activities are typically conducted at the time when needed later during project implementation.) The baseline needs to include an estimate the resources required for these analyses.

Ready for Implementation

The ultimate outcome is to enact an A/B change and/or delineate any special provisions, protocols, and procedures that will need to be incorporated into work packages for execution of the project scope.

All A/B revisions must be complete. NCSE input to design of processes to support D&D are used within other activities as appropriate.

Many analyses will not be conducted prior to CD-3 because the work is not defined until task-specific procedures and work packages are developed. Analyses that would typically be conducted later during implementation include:

- NCSEs for processes to support D&D, such as material stabilization and to support work packages for removal of equipment that has residual fissile material.
- USQ evaluations for review of project activities subject to the scope of the A/B.

The work documents for which these are needed cannot be prepared early because prerequisite work, such as removal of surrounding equipment, must first be completed and the resulting physical configurations are known.

Activity #7 Facility Condition Assessment

This activity:

- Ensures the safety of personnel during D&D operations.
- Determines current physical conditions for establishing the project baseline.

Description

When a facility is transitioned to D&D, the project team must assess the physical condition of the facility with primary focus on safety of D&D personnel who will work in and around the facility. The structural integrity of roofs, walls, floors, stairs, surrounding soils, etc. must be evaluated. Radiological safety, industrial safety, and industrial hygiene surveys must be performed.

This early facility characterization is not intended to acquire the level of detail that will eventually be needed to complete D&D of the facility. It is focused more on identifying personnel hazards than on characterizing facility SSCs for disposal as waste. This more comprehensive characterization for waste disposal will be done later. However, the chemical, radiological, and physical hazards must be identified so that corrective actions can be specified to ensure that D&D personnel can safely perform the work. Understanding of these hazards will be required for the job hazards analyses that will be conducted during approval of the field work packages.

Abandoned or legacy facilities are those that ceased operation long ago and for which there is little current operating knowledge base. For these facilities, a significant effort will likely be required to identify and evaluate existing conditions before determining and taking appropriate actions.

Engineering/Design Indicators of Significance

Facility condition assessment is not likely to require detailed engineering/design deliverables for the baseline because the scope is limited and methods are well understood.

Concept Development

The physical condition of the facility must be assessed by the end of this phase. This is most effectively done by walking down the facility with a multidiscipline team shortly after it is identified for transfer to the D&D program.

Facility, system, and hazardous material conditions are identified and documented in a report, which then forms the basis for the actions that must be completed to allow D&D personnel to work safely in the facility.

In summary, the objectives of the facility walkdown and associated data gathering activities are to:

- Ensure that sufficient information has been collected, assembled, and analyzed to provide an understanding of existing conditions and hazards
- Identify any additional characterization needed
- Identify and allocate resources needed to maintain stable and known conditions of the facility, its systems and equipment pending disposition
- Permit effective D&D planning
- Minimize risk to project baseline cost and schedule due to scope increase as a result of late discovery of unexpected conditions
- Identify required stabilization (e.g., structures, materials, etc.) activities

A report should be prepared to document the results of the facility walkdown and associated activities. The following information should be considered for inclusion in the report:

- An operating history (including previous operational records) of the facility, providing the process knowledge of the nuclear and chemical materials that were handled and major upsets (e.g., spills or leaks) and accidents that occurred.
- A description of the condition of all structures, existing engineered protective barriers, and systems installed to prevent migration of both hazardous and radioactive contamination to the environment and that ensure the safety of workers, the public, and the environment.
- A description of the nature, levels, and probable extent of the existing hazardous chemical contamination, the radiological contamination, and direct radiation fields within and around the facility.
- An accurate and complete inventory (including associated uncertainties) of types, forms, quantities, and locations of all special nuclear and fissionable materials.
- An inventory or estimate and the locations of the remaining hazardous material, waste and chemical inventories, and any associated uncertainty. This should include form and distribution information.
- The occupational hazards associated with the facility. This evaluation should focus on fixed hazards.
- Current radiological survey data used to:
    - Identify barriers necessary to protect the public and the environment
    - Define the radiological working conditions, equipment (e.g., containment, protective clothing, etc.) or procedures that protect the worker

Development of Baseline

The facility condition assessment report should be used as a basis to identify work scope that must be incorporated in the project baseline. For example, if the assessment identifies significant structural deficiencies in the facility, major facility modifications may be required to allow safe entry of D&D workers. Additionally, if the condition assessment indicates large areas of radiological contamination with the potential to become airborne, the project baseline must include scope to provide the required radiological monitoring and protection equipment, such as constant air monitors and breathing air supply, as well as identifying areas where there is a potential for use of fixatives.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers and project team that will be conducting the activity.

Ready for Implementation

All the actions needed to mitigate conditions identified in the condition assessment should be in place at the end of this phase.

Activity #8 Characterization of SSCs and Process Materials to be Disposed as Waste

This activity:

- Characterizes SSCs and their contents (wet and dry solids, and liquids, nuclear materials, etc.) to provide input to waste management activities (see Activities #27 through #31).
- Characterizes waste to establish waste profiles for transportation and disposal and for Waste Acceptance Criteria (WAC) compliance.

Description

Prior to the start of full-scale D&D activities, area radiation and surface contamination surveys will be needed to establish waste profiles for disposition planning. This characterization data also supports development of D&D approach planning.

Early in the project, characterization/data acquisition proceeds from the general to the specific. First, process knowledge is applied as to what operations occurred in each room of the building. This may suggest what type of materials may still be present as contamination on room surfaces and in remaining equipment. Where the project involves a reactor or accelerator, characterization for activated metals is also necessary. Radiation surveys (using alpha and beta-gamma instruments) and inspections of equipment interiors (using for example visual observation, remote camera entry, and nondestructive examination) are then conducted. When knowledge about the composition of radioactive materials is needed and process knowledge is not available, sampling or other in-situ techniques are conducted. When the existence of residual nuclear materials or significant nuclear material contamination is possible (e.g., in glovebox lines), NDA methods are appropriate.

During project implementation, characterization occurs continuously to support work activity planning, personnel protection, and waste generation/packaging. In many projects, the need for characterization results in a comprehensive set of facilities, equipment, and analysis methods.

Engineering/Design Indicators of Significance

Characterization is likely to be a significant engineering/design element of the project when:

- The facility is heavily contaminated and/or historical documentation and process knowledge of the facility are lacking.
- The facility contains large amounts of process equipment, the materials processed in the facility were highly radioactive, fissile, reactive (e.g., shock sensitive, pyrophoric), or toxic materials are present (e.g., RCRA metals such as mercury, lead, chromium).
- The project will be generating TRU waste, which in most cases must be transported to the Waste Isolation Pilot Plant (WIPP), and therefore must be characterized to meet stringent transportation requirements and the WIPP WAC.
- The facility processed a wide variety of materials with differing compositions, thus requiring segregation of the waste into discrete waste streams for shipping to the appropriate disposal facility.

Concept Development

Characterization planning and D&D approach selection (Activity #1) go hand in hand. At this phase of the project, emphasis is on understanding what is known about the facility and what “unknowns” need to be addressed through characterization.

Creating detailed listings of the SSCs, process knowledge of their likely radiological and chemical characteristics, and their locations to be characterized are the primary objectives of this phase for characterization planning.

Characterization is also an important concurrent activity for waste management planning (Activity #28, Waste Identification and Planning). Activity #28 should identify all the major SSCs, process materials, and residues that will be removed and disposed as well as the quantities and types of waste generated during D&D operations, including soil removed with slabs and foundations as part of demolition. This planning will serve as the basis for waste characterization planning.

Development of Baseline

A comprehensive characterization plan should be developed to address the characterization activities for all project activities and the resultant waste types that will be generated by these activities. The characterization plan includes:

- Gap analysis identifying what information needs to be confirmed, and what missing information needs to be obtained,
- Description of sampling methods and estimate of the number of samples to be taken from area/items to be characterized,
- Analyses to be conducted, anticipated methods and targeted analytes,
- Survey methods and related scaling factors,
- Laboratory facilities, on-site and off-site; if existing on-site facilities are to be used, the plan should address functional readiness and the activities required to achieve it. (If a newly constructed on-site laboratory facility will be used, the engineering/design review should follow DOE O 413.3A guidance for design-build projects),
- Identification of facilities and equipment for sampling and surveying (e.g., low background or shielded areas),
- Drivers for characterization such as disposal site WAC and transportation regulations.

The cost and schedule impact of executing the characterization plan is incorporated into the project baseline for each project activity where SSCs or process materials will be removed or where waste will be generated.

For some projects, high technology methods (e.g., remote devices) may be needed to obtain characterization data. In such cases, characterization planning should include functional requirements and the details conducted as Activity #16, Technology Application.

Ready for Implementation

At the end of this phase, characterization work packages should be complete and ready to work. This is particularly important if sampling and certified lab analyses are required.

Specifications should be prepared for procurement of laboratory services, equipment, construction of on-site facilities for sampling/surveying, and services to be provided on site.

Activity #9 Characterization for Compliance

This activity determines compliance with several regulatory requirements and commitments.

Description

Surveys and sampling will need to be conducted during the course of D&D activities for personnel exposure management, environmental release monitoring, and to ensure clean-up standards are met. The sampling and survey results will be used to confirm compliance with internal project and external regulatory commitments such as:

- Verifying end points have been achieved where verification is by sampling, survey, and/or analyses.
- Meeting RCRA criteria for allowable residual contamination within systems that contained hazardous materials
- Accountability for removal of nuclear material
- Meeting criteria for post-demolition residual radiation and surface contamination.

See Activity #8 for characterization to support baseline development and waste management.

Possible Variations

Although the primary focus of D&D projects is with management of radiological contamination and compliance with associated cleanup standards, certain projects may involve non-radioactive hazardous or toxic contaminants. The sampling and analysis techniques for these constituents are somewhat different than those for radiological contaminants. However, the approaches to characterization planning and compliance attainment are similar. Therefore the material presented for this activity may be generically applied for all compliance scenarios.

Engineering/Design Indicators of Significance

Characterization for compliance is likely to be a significant engineering/design element of the project when high radiological exposure rates and/or contamination are present, RCRA materials are present, or project activities include removal of SNM.

Concept Development

This activity develops the overall scope of resources and services needed for compliance characterization. However, sampling and analysis is generally addressed in the BOE on *an individual activity basis* and not in an integrated manner.

However, for overall project planning, decisions are needed regarding the availability of on-site resources (technicians and labs) and off-site resources (e.g., laboratory services).

Engineering activities to support this planning involves identifying project activities and evaluating the total magnitude of sampling, surveys, and analyses will be needed for complying with regulatory and project requirements.

Development of Baseline

Compliance characterization planning includes:

- Drivers for characterization such the criteria and protocols that depend on the types of tasks.
- Sampling methods and number of samples to be taken based on likely radiological and chemical characteristics, locations to be characterized, and established protocols (e.g., for accountability).
- Analyses to be conducted, methods anticipated, and analytes targeted.

- Survey methods and related scaling factors.
- Laboratory facilities, on-site and off-site.
- Availability of technicians for conducting surveys and taking samples.
- Facilities and equipment for sampling and surveying (e.g., low background).

The number of samples and analyses are estimated and a unit cost applied for baseline development. The cost and schedule impact of executing the characterization plan is incorporated into the project baseline.

Baseline considerations may also address:

- Scope, cost, and schedule for adding on-site analysis capability.
- Technology needs (e.g., remote devices) to obtain characterization data (See Activity #16, Technology Application).

The deliverable is a plan to address the compliance characterization activities for all project tasks. The plan should identify where Data Quality Objectives (DQO) are needed. Creation of each DQO is part of the specific activity to which it applies.

Ready for Implementation

From an overall project perspective, specifications should be prepared for procurement of laboratory services and equipment. Construction of additional on-site facilities for analysis is addressed as a design and fabrication activity.

Otherwise, the technical details of sampling, surveying, and analyses for implementation are left to the individual project activities that they support.

Activity #10 Equipment Dismantlement and Removal

This activity identifies and removes equipment to achieve the D&D end points.

Description

While it is often beneficial to leave as much equipment as possible for "demolition in place" along with the building structure, some SSCs may need to be removed in advance of demolition for the following reasons:

- Nuclear material removal, reducing to facility source term, thus allowing a reduction in facility hazard category
- Contamination removal
- Asset recovery
- Scrap recycle
- Component segregation to ensure conformance to disposal WAC
- Security issues associated with the equipment design which result in special disposal requirements
- The inventory of accountable nuclear materials assigned to the equipment may require special disposal
- To be assayed to ensure compliance with disposal facility WAC when in-situ assay is not acceptable
- To package for transport to the disposal facility in situations where in-situ size reduction is not possible or desirable
- To be cut open for visual inspection, sampling or removal of residual process material, where specially designed cutting equipment has been made available for this purpose

Planning includes tool selection for equipment removal and/or in-situ size reduction and removal path selection, including possible structural modifications to facilitate removal.

It may be desirable to segregate the more highly contaminated process equipment from the less contaminated building structure. For instance, in the situation where the facility end state was determined to be demolition to slab, it is possible to dispose of the building debris as low level or even sanitary waste, whereas the equipment my require disposal as a more expensive waste form, such as TRU waste. Segregation to minimize the volume of the more expensive waste forms is good practice. This segregation is possible after demolition, but is more difficult to execute. In the situation where in-situ decommissioning is the final end state, it may be desirable to remove some equipment to reduce the source term to meet performance assessment criteria.

Possible Variations

Equipment removal could involve reactor vessel removal or reactor internals disassembly. Design considerations for removal need to take into account the size and complexity of these vessels (often weighing several tons), and the very high radiation levels due to activation of the metallic components. Removal is a complex undertaking since the reactor vessel is usually set in place before fabrication of the containment structure is complete.

Equipment removal could also be shield block disassembly. Some types of process or research equipment (i.e., accelerators) are housed within secondary, shielded enclosures (like massive interlocking concrete blocks). In most cases, it will be necessary to disassemble and remove the shielded enclosure prior to removal of the equipment.

Engineering/Design Indicators of Significance

Equipment dismantlement and removal is likely to be a significant engineering/design element of a project when the project scope includes a large quantity of equipment or a large complex piece of equipment must be removed for the reasons cited above.

Concept Development

At the project conceptual phase, identify:

- Equipment that will require dismantlement and removal.
- The general condition of equipment to be removed, including content (e.g., the presence of liquids, sludge, gas), and contaminants (types and levels).
- Specialized equipment requiring design to dismantle and remove the identified equipment (e.g., for large shield blocks, large vessels, large quantities of interconnected items, large machinery)
- Preferred approach (e.g., removal in entirety or size-reduced; removal pathways, and special handling needs)
- Mockups needed for dismantlement/disassembly planning and craft training (see activity #15).
- 3D Computer modeling needed for removal planning and identification of interferences along removal/transport pathway.

Development of Baseline

Baseline development includes:

- Engineering for disconnection of the equipment from the system/facility where it is located. This includes addressing electrical connections (e.g., power supply and I&C) and mechanical connections (e.g., process flow, compressed air, service or cooling water). Disconnection from equipment pedestals and foundations should also be addressed. Deliverables include:
    - Work scope for disconnection
    - Marked-up drawings identifying disconnection locations
    - Specifications for how each location is to be physically terminated and isolated from it's source
    - Test requirements for integrity of terminations and closures
- Engineering (as needed) for draining equipment prior to removal. Tap and drain operations are further addressed in Activity #12. Deliverable related to equipment draining prior to removal include:
    - Identification of drain location
    - Identification of liquid/sludge removal method
    - Collection method
    - Marked-up drawings identifying drain location(s)
- Engineering for dismantlement/disassembly of the equipment to facilitate removal (or provide access to internals for decontamination or removal of residuals). This includes addressing at a component level-of-detail, the sequence of actions for disassembly and removal and the appropriate type of tools and fixtures that will be required. Deliverables include:
    - Work scope for dismantlement/disassembly
    - Equipment drawings

  - Listing of special tools & fixtures
  - Sketches of special tools & fixtures
  - Sequence of dismantlement/disassembly actions when important
- Engineering for rigging and lifting to ensure equipment can be safely removed. This includes verification of lifting lug capacity (or design of new lifting lugs if needed), identification of rigging components (e.g., slings and shackles) and special rigging devices (e.g., spreader bar), and lifting zone to ensure there is no interference from other equipment. Deliverables include:
  - Calculations for lifting lug design, rigging selection, and crane capacity
  - Sketches of rigging configuration
  - Lifting & Rigging Plan
  - Determination of crane or lifting device (e.g., type, capacity)
  - Test load requirements
- Engineering for transport of the equipment within the facility to verify it can be safely removed and transported out of the facility (e.g., over floors and/or roofs, through existing passage ways). This includes addressing packaging needs to control the spread of contamination. Deliverables include:
  - Marked up arrangement drawings depicting equipment transport path
  - Calculations for floor loading analysis
  - Calculations for modifications to existing passageways or design of new passageways.
  - Design and specification of contamination control devices/materials
  - Design of transport cart or dolly, if required.
  - Design for removal of interferences
- Engineering of shielding to minimize radiation exposure to workers. Deliverables include:
  - Calculations to determine appropriate thickness of shielding material.
  - Specification of shielding material, material form (e.g., shot, sheet, bricks, liquid), and configuration.
  - Design of shielding supports and/or attachment mechanism.
  - Arrangement drawings
  - For large scale implementation, this is further developed in Activity #17
- Engineering of setup for characterization. Deliverables include:
  - Specification of location where characterization is to be conducted
  - Identification of required characterization equipment
  - Arrangement drawings
  - For large scale implementation, this is further developed in Activity #8.
- Identifying the approach for transport to the disposition location. Deliverables include:
  - Identification of transport mode

  - Functional requirements for special handling, adapters, inserts, contamination isolation
  - For large scale implementation, this is further developed in Activity #31
  - Identifying specialized resource needs such as rigging craft support and structural engineering support.

Ready for Implementation

Deliverables include:

- Work sequence/installation instructions and engineering requirements input to work packages and procedures.
- Procurement specifications for materials, equipment, and services.

Activity #11 Size Reduction

This activity cuts equipment into smaller pieces for removal and/or shipping.

Description

Process equipment may require size reduction in order to facilitate removal and/or packaging for waste disposal. Cutting equipment and techniques include nibblers, saws, shears, thermal cutting (either flame or arc producing), water jets, and abrasives. Additional considerations for size reduction campaigns include:

- Design of facilities in which to conduct cutting operations
- Integration with related processes such as surveying.
- Planning as a campaign when there is much equipment to be size reduced (e.g., glovebox lines).

Size reduction is very labor intensive and increases the potential for spreading contamination. As such, trade-offs with other approaches need to be considered when formulating the project baseline. Examples of alternative approaches include:

- Decontaminating a glovebox to less than 100 nCi/g TRU to allow disposal as LLW and eliminate the need to size reduce the glovebox for packing into standard waste boxes (SWBs) for disposal at WIPP.
- Placing large components on a pallet and applying InstaCote® spray fixative and shrink wrap to qualify the item as an Industrial Package (IP-1) transportation package instead of cutting up the component to fit in conventional waste packages.
- Cut items into manageable sized pieces during removal, especially in the case of process piping and vessels, instead of utilizing a dedicated off-line size reduction facility for bulk size reduction.

Engineering/Design Indicators of Significance

Size reduction is likely to be a significant engineering/design element of the project when:

- The project scope includes a large quantity of items that must be cut up into smaller pieces for removal or packaging for transport (e.g., gloveboxes, process vessels).
- Items requiring size reduction have high contamination and/or radiation levels, therefore requiring special containments and/or remote handling and cutting techniques.
- Items requiring size reduction contain TRU contamination or residual hazardous material.

Concept Development

Identify equipment that will require size reduction for removal or packaging along with the size reduction method(s). As part of concept development, several subjects need to be addressed including:

- If the project scope includes a significant number of items that require size reduction, an evaluation should be considered for setting up centralized size reduction within the facility versus in-situ size reduction.
- Evaluate which equipment can be removed without size reduction for direct disposal.
- If there any challenging items, such as large/heavy machinery or and/or equipment with complex geometry, evaluations should be considered for methods and tools to be used.
- If thermal cutting methods are to be used, the fire protection provisions must be reviewed; and if necessary, engineering of additional detection/suppression conducted.

- Evaluate the need for modified ventilation (Activity #21), temporary ventilation (Activity #22), and temporary enclosures (Activity #24).

Development of Baseline

Baseline development includes:

- Defining the work scope and strategy of size reduction operations for major equipment (e.g., vessels and tanks) or defining the size reduction campaign for similar types of equipment (e.g., extensive process piping or complete glovebox lines).
- Specification of size reduction methods (e.g., mechanical cutting, thermal cutting, compaction, shredding, hands-on disassembly) and requisite tooling.
- Engineering for size reduction of equipment. This includes addressing at a component level-of-detail, the sequence of actions for size reduction and the appropriate type of tools and fixtures that will be required. Deliverables include:
    - Identification of system/components to be size reduced & their locations in the facility/system
    - Informational photos and drawings
    - Equipment drawings depicting appropriate locations for cutting
    - Size reduction activity flow diagrams
    - Specification of any specialized cutting equipment needed
    - Sketches of special tools & fixtures
    - Sequence of size reduction actions when important
- Engineering for support systems for size reduction activities. Deliverables include:
    - Specification of ventilation requirements (see Activities #21 and #22)
    - Specification of contamination control techniques
    - Specification of enclosures and containments (see Activity #24)

For decisions to create a central size reduction facility, the engineering/design review should follow DOE O 413.3A guidance for design-build projects.

Ready for Implementation

Implementation development includes:

- Engineering requirements inputs to work packages and procedures
- Procurement specifications for materials, equipment, and services.

Activity #12 Liquid Flush and Drain

This activity removes chemical and radioactive liquids and particulate from equipment and liquid systems for safe conduct of related D&D.

Description

Considerable effort may be required to plan, engineer, and execute work to safely remove liquids remaining in equipment, liquid systems, and basins (i.e., fuel pools). Reasons for removal include:

- Minimizing inadvertent leakage for safety of D&D workers who will remove:
    - liquid system components
    - equipment containing liquids such as gloveboxes, oil lubricated machinery, storage vessels
- Disposal of bulk liquids.
- Immobilizing to prevent inadvertent relocation of contaminants within systems.
- Reducing radioactive contaminants to reduce area and handling dose rates and/or to facilitate waste disposal.
- Capturing nuclear material inventory to ensure inadvertent criticality is not possible; similarly for reactive organic or pyrophoric materials.
- Reducing concentration of RCRA hazardous chemicals (acids, caustics) to below allowable minimums.

Flushing and draining operations usually occur in the early phases of a project. As a result, comprehensive planning should be started early. Liquid removal campaigns must consider the following:

- In general flushing is performed to remove or reduce the concentration of contaminants whereas draining is to remove residual heels. Where both types of operation are to be conducted, flushing will precede final draining. The residual materials removed by flushing are typically not tightly bound to equipment surfaces. Although infrequent for D&D projects, aggressive mechanical or chemical decontamination may be needed if contaminants are tightly bound to internal surfaces. One advantage for aggressive decontamination of systems in a D&D project is that impacts on long-term system integrity are not a concern.
- Such campaigns may require design of temporary systems designed to standards consistent with the liquid being moved.
- Drain planning must assume liquid heels reside in all low points until proven otherwise. Draining involves opening system vent and drain valves to allow residual liquids to gravity flow to collection locations; however, drains are usually not installed at all low points in a system. Therefore, all the low point locations must be identified. Similar considerations apply to sumps and tanks that may have residual heels after draining or loss of drain pump suction. A drain campaign usually involves use of features that are not part of the installed systems; examples include hot-taps[2] for piping and pumps or vacuum transfer for vessels.
- Removal of bulk liquids from large tanks and basins in many cases are a campaign of their own, especially when treatment is required.

[2] A "hot-tap" refers to devices by which a valve can be connected to a pipe without exposing the interior to the surroundings. The valve stub is first welded to the side of the pipe and a sealed drill bit is used to create the opening.

- Treatment encompasses processes such as filtration, precipitation, neutralization, evaporation, ion exchange, and absorption. The waste resulting from such processing can be a significant consideration for liquid campaign planning (Activity #27). The degree of draining, flushing and decontamination to be conducted may be evaluated by tradeoffs for costs versus savings achieved for disposing of less contaminated equipment.

Possible Variations

It may be necessary to employ aggressive chemical decontamination processes in cases where large deposits or residuals tightly adhered to equipment surfaces exist. In extreme cases, the use of mechanical decontamination processes (e.g., flex hone or pipe pigs) may be required. Although the use of these aggressive processes for system decontamination is infrequent for D&D projects, one advantage for this application is that impacts on long-term system integrity are not a concern. Many of these processes are available as vendor-supplied "package systems" or services. The design considerations in this case would include system interface, utility connections, and contamination control measures.

Engineering/Design Indicators of Significance

Flushing and draining of liquid systems is likely to be a significant engineering/design element of the project when:

- Systems contained particulate or dissolved chemicals, radioactivity, or reactive materials (fissile or pyrophoric materials).
- There are a large number of systems and the number of components (piping, valves, filters, traps, separation columns, tanks) in systems.
- Cramped or high overhead locations make for difficult access for draining.

Concept Development

For all but the simplest systems, a comprehensive and rigorous plan is required to implement system flushing or a tap & drain campaign for removal of heels and residual liquids. Comprehensive planning should be conducted early in the project. Planning should identify all systems and major components, the physical bounds of each campaign, fluid pathways, collection methods, liquid treatment methods, and disposal pathways for the flush and drain liquids as well as materials resulting from treatment (e.g., ion exchange or filter media).

Concept development includes completion criteria. Requirements for completion of flushing can be stated as maximum chemical concentration, external radiation dose rate, particulate capture on filters, and/or visual clarity. Completion of a tap & drain will usually require a visual method to ensure free liquid has been removed from vessels and piping low points.

Development of Baseline

Baseline support must address engineering and operations. Baseline development includes:

- Planning and Engineering the process. Deliverables include:
    - A description of how each campaign is to be conducted and the duration for doing so, including preparation time. Evaluating the schedule for conducting each campaign is important because resources will be required for the entire time. In addition to the management team, required skills can include operations, engineering, chemistry support, health and safety, radiological controls, nuclear safety, offsite laboratories, and craft support (e.g., laborers, riggers, drivers, pipefitters, machinists).
    - Specification of flush solutions.
    - Identification and estimates of the types and quantities of liquid to be removed.

- Engineering the physical configuration, for which deliverables include:
  - New or marked up drawings for the flush paths and valve lineups.
  - For tap and drain, informational photos and drawings, including isometrics as appropriate where gravity draining is to be conducted, showing vent and low point drain locations.
  - For flushing, informational photos and drawings showing flush supply and removal connections.
- Engineer support equipment and systems and connections to the system
  - Marked up drawings, photographs, and equipment lists to identify equipment and connection points for flushing /draining and purging/venting.
  - Details of receiving vessels for draining.
  - Details of supply source and pumping methods for flushing.
  - Structural, electrical, and ventilation requirements, as appropriate.
- Identify procedural requirements
  - Readiness requirements prior to initiating a campaign.
  - Sequence of steps for flushing and tap & drain.
  - Special precautions for personnel safety.
  - Contamination control techniques.
  - Liquid waste management requirements.
  - Method for verification of completion.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures
- Procurement specifications for materials, equipment, and services.

Activity #13 Surface Decontamination

This activity decontaminates surfaces to meet D&D end points.

Description

This activity may be required to:

- Reduce radiation dose to D&D workers
- Reduce potential for airborne contamination, allowing D&D personnel to work without respiratory protection, thus improving efficiency
- Support open-air demolition
- Reduce the contamination level on items to be disposed as waste to the extent that the items can be disposed via a lower cost path (e.g. reduce waste classification of TRU to low level or from low level to sanitary).
- Achieve final decommissioning or deactivation end point criteria

Methods may range from simple surface wiping to sophisticated chemical (e.g., strong mineral acids, foams and gels, chelating agents, oxidizing and reducing agents, proprietary commercial products) and physical (e.g., strippable coatings, shot blasting, grinding, shaving, spalling, scabbling, high pressure water) treatment of equipment, walls, and floors.

The type of contamination to be removed may include loose or weakly bound “removable” surface contamination, strongly bound “fixed” surface contamination, or volumetric contamination present at depth relative to the surface. The last type may be present at depth because the porosity of the contaminated material may have allowed the contaminants to be transported into the material or the material may have been activated at depth due to neutron radiation. Porous surfaces, such as concrete are difficult to decontaminate, without physically removing the surface layer. In the case of concrete, it is rarely necessary to remove more that ¼ inch of the surface material for radiological contaminants other than tritium.

For situations in which the contamination does not pose a radiation hazard, but is a concern because it is easily spread and/or tends to become airborne as result of D&D work activities, it may be more cost effective to simply apply fixatives to the surfaces to immobilize the contamination rather than remove it.

Possible Variations

Decontamination could be a sludge removal campaign. Removal of sludge deposits from fuel pools (basins), sumps, building basements, and tank bottoms pose many challenges due to the adherent nature of sludge, lack of accessibility to the area, radiation levels (which in some cases can be very significant and require removal operations to be conducted remotely under water), and often the chemical/radiochemical composition of the sludge (i.e., presence of fuel particles). Design considerations include selection of the removal process (i.e., vacuuming, air lifting, high-pressure flushing/scouring), method of collection of solid debris, criticality control, maintaining visibility (for underwater operations), and final dewatering of collection containers.

Engineering/Design Indicators of Significance

Surface decontamination is not likely to require detailed engineering/design deliverables for the baseline because the activity is a standard and routine practice.

Exceptions are in cases that involve a large, extensive area or an item with a complex geometry.

Concept Development

Identify the nature (constituents, mobility, etc.) and extent (estimated area) of the chemical and/or radiological contamination on surfaces that need to be removed or reduced for the reasons discussed above.

Development of Baseline

Evaluate the degree to which surface decontamination should be conducted by considering the tradeoffs among the cost of surface decontamination and benefits to be gained in personnel dose, airborne contamination and waste disposal cost reduction. In some cases, application of fixatives may prove sufficient in lieu of decontamination.

Evaluate and select the optimum decontamination methods (mechanical, chemical) for the type, location, and area of contaminated surface in the facility. Pilot testing may be needed to select among preferred mechanical methods and chemical reagents.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specific direction for decontamination approach and sequence; design of decontamination equipment, containments, and temporary ventilation (if required); and any requirements for specialized worker training on equipment.
- Procurement specifications for materials, equipment, and services.

Activity #14 Fixative Application

This activity addresses contamination concerns through the use of fixatives to minimize potential for airborne contamination and prepare surfaces and/or equipment for demolition.

Description

The application of fixatives may be a cost-effective alternative to surface decontamination.

Fixatives are used to:

- Immobilize contaminants
- Reduce potential for airborne
- Support equipment packaging for transport
- Control the spread of contamination during equipment removal and demolition activities
- Support "open-air" demolition of structures
- Provide a physical and/or visual barrier for classified items

Fixatives, especially expanding foam, can be used in pipe segments and vessels/tanks to immobilize special nuclear material (SNM) residuals and prevent relocation into a critical mass and also eliminate void space.

Possible Variations

A common end state for D&D projects is slab on grade where the removal of the slab and final soil remediation will occur at some point in the future. Protection of the slab from the elements during this interim time can be accomplished with durable fixatives or epoxy coatings. The purpose of the coating is to prevent degradation of the slab leading to migration of contaminants from the slab and the soil under it. Application of the coating is generally straightforward, following manufacturer's instructions.

Engineering/Design Indicators of Significance

Fixative application is not likely to require detailed engineering/design deliverables for the baseline because the application of fixatives to surfaces to reduce potential for the spread of contamination is a fairly standard and routine practice

Exceptions are in cases where a large, extensive area or an item with a complex geometry requires application of fixative; or the contaminant is easily dispersed (like Pu-238).

Concept Development

At the conceptual level, it will be necessary to identify the area/items to be coated with fixative, and the basic type of fixative to be utilized (e.g., aerosol fog, spray-on coating, and expanding foam).

Development of Baseline

The engineering/design activities required for a reliable baseline cost and schedule includes:

- Selection of fixative type, with vendor involvement to identify best product for specific application and proper deployment technique.
- Mock-up testing to verify effectiveness (potentially).
- Identification and specification of fixative deployment equipment, containment, and temporary ventilation needs.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specific direction for fixative application approach and sequence; design of deployment equipment, containments, and temporary ventilation (if required); and any requirements for specialized worker training on deployment equipment
- Procurement specifications for materials, equipment, and services

Activity #15 Mockups

This activity improves operational proficiency for challenging stabilization, decontamination, and cleanout activities by providing worker input to processes and designs. Mockups are also used to debug and optimize application of technologies to specific situations.

Description

Project engineers decide the scope, specify the functions, design, and facilitate the construction of mockups that will be used to reduce uncertainty from the conduct of specific steps during D&D. They must also arrange for results from using the mockups to be incorporated in D&D operations, equipment modification, and in the design and procurement specifications for new equipment.

Primary reasons for mockups are:

- To assist with development of design details. In particular, plant operations and maintenance staff input to engineering/design that support deactivation activities can be very useful. Examples of a few such activities include development of fixtures, tools, and temporary systems for purposes such as equipment size reduction and removal, cleaning out vessels, waste processing, and decontamination.
- Proof of feasibility for adapting vendor and laboratory technologies to specific problems. An example would be to replicate the course that a remotely operated device must navigate to collect data or obtain samples.
- Development of operational procedures and tools, along with subsequent training in application, to address complex D&D tasks in which an error can result in a worse situation or present a threat to personnel or environmental safety. Examples of such operations include underwater or standoff (due to radiation) disassembly of components, retrieval of items from underwater or tight access locations, and similarly operation of cleaning equipment in difficult configurations.

In most cases, a partial representation is all that is needed to support a design decision or adaptation of a technology. In other cases, such as for continuous operator training, a more complete and robust mockup may be needed.

Engineering/Design Indicators of Significance

Mockup development is not likely to require detailed engineering/design deliverables for the baseline because the scope is usually very limited and the need is temporal.

Exceptions are in cases where the mockup is very large and/or a high precision is needed for representing the field configuration and/or materials.

Concept Development

When it is decided a mockup is needed, several questions must be evaluated and the functional requirements must be stated; for example:

- The purpose, related to the reasons above, and specific objectives stated
- Scope of the mockup in comparison with the design scope or actual field configuration. In many cases, the mockup will only represent a portion of the application.
- Precision, or fidelity, of the mockup to the actual situation. Depending on the purpose, there may or may not be a need for dimensional accuracy.
- Types of materials to be used. Mockups are generally made of wood, steel, plastic, or some combination. Considerations of materials may be based on whether there is a need to replicate the materials in the actual application, or perhaps on the availability of materials and related fabrication capability (shops, craft skill).

- Personnel skills to be involved in exercising and using the mockup. These will be from the facility or contractor field staff as well as engineers and designers that will use the results.

The requirements should be documented for each mockup.

Development of Baseline

The design of a mockup will require drawings, sketches, and/or other documents that provide typical design details. If there are existing design drawings that provide dimensional information for the field application, there may not be a need to create new drawings for the mockup.

Details for fabrication and assembly are needed since these are usually quite different than the actual assemblies. Large mockups will require engineering/design for structural integrity and structural safety, which will require drawings, material specifications, and assembly specifications.

In cases where the mockup itself represents a significant element of the project cost or will be used over an extended duration, it should be included in the project baseline estimate and schedule.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers and project team that will be conducting the activity.

Ready for Implementation

Implementation of a mockup is its use for the stated purpose. Final design is completion of that which was started for baseline development. In cases where a mockup is for the purpose of determining details of the design it represents, there may be no final design of the mockup itself.

In cases where the mockup is for operational support, if the need is not during the early phases of implementation, final design may not be necessary until after CD-3.

When appropriate, provide procurement specifications for materials, equipment, and services.

Activity #16 Technology Application

This activity plans, engineers, and conducts proof-of-principle testing/demonstration for application of new technology or adaptation of existing technology to project conditions.

Description

Conduct of D&D frequently encounters problems for which technological methods (e.g., robotics) are available but not directly useable for the specific situation. In some cases, the problem being addressed may be a major challenge at a project level (e.g., pumping sludge from spent fuel pools, size reduction of a large number of glovebox lines). In other cases, it may be an impediment to a limited activity (e.g., photographing a location that is inaccessible by humans).

This activity is purposefully for *application* of technology; not research and development. That is, adapting existing technology to address specific constraints, such as accessibility, location environment, radiation, materials encountered, and to carry out tasks such as measurement, cutting, and removal of items.

Engineering/Design Indicators of Significance

Application of technology is likely to be a significant engineering/design element of the project because *any* adaptation of a technology to a specific application will be complex, given the steps needed for design, prototypes or mockups, testing, analysis of testing and modifications as a result of tests, fabricating and assembling the equipment to be placed in the field, deployment, field testing, and creating procedures for operations.

In addition, it is important to understand if introducing a new technology will have an impact on or be impacted by the safety authorization basis (A/B). A hypothetical example is a technology that uses water or hydraulic fluid may not be allowed in locations where there are stringent constraints to prevent nuclear criticality. Early identification, engineering/design, and integration of the technology's compatibility with the existing safety authorization bases, or potential modification of either the technology or the A/B, are necessary.

Concept Development

Project engineers identify needed adaptations of a technology to a challenge specific to the project. They will describe the need, investigate technological alternatives, consult with experts, arrange for vendors or research organizations to adapt and test candidates, conduct focused workshop, review the results for applicability and effectiveness, and design the implementation.

A project document should record the need, the technology selected, and how it is to be applied. Identification of the technology’s compatibility with the existing A/B and potential revision should be addressed. Interfaces with the facility and its systems should also be described.

Activity #15, Mockups, is frequently used to demonstrate feasibility and to derive operating steps for technology application.

Development of Baseline

Once feasibility is demonstrated, engineering to support baseline is conducted. The baseline scope and estimate must address all the steps and support required for fabrication and delivery of the field device(s), their deployment, and field testing. The baseline schedule must address the time required development of application, testing, and placement in the field. Critical path dependencies and their impact on the overall project schedule are especially important.

Information sufficient to support the baseline can involve activities such as:

- Creating prototype(s).

- Specifying, conducting, evaluating, and reporting results of tests and demonstrations.
- Defining steps for application.

Deliverables include:

- Fabrication details of how the technology is to be adapted, including material specifications and design drawings for procurement or on-site shops.
- Details of the interfaces with the existing facility (e.g., installation location) and its systems (e.g., electrical, pneumatic, and water). Can involve arrangement drawings, connection diagrams, access pathway sketches, structural attachments, and others.
- Plan for in-facility testing and readiness review.
- Descriptions of operations and estimates of resources for implementation, including training.

Ready for Implementation

Final design completes the details for supplying, installing, and testing the technology that has been selected and demonstrated. Procurement specifications for materials, equipment, and services are created.

Activity #17 Shielding

This activity analyzes, designs, and specifies shielding as one element of radiological engineering.

Description

Shielding is one element of radiological engineering aimed at reducing personnel exposure to radiation. Radiological Engineering, in the broader sense, is addressed in Activity #42. The engineering/design tasks related to shielding include selection of materials and equipment and specification of installation methods.

Engineering activities during design phases will generally be where there is a need for robust semi-permanent shielding. It should be noted that engineering will tend to be very conservative and design for the worst case dose rate. However, this may result in shielding so bulky as to interfere with operability (e.g., limiting the reach through glove ports). For D&D work, in many cases it is prudent to plan to add shielding in the field based on measurements of dose rate.

Possible Variations

Removal of highly contaminated cartridge filters from process systems or removal of highly activated components from fuel basins or hot cells may require the use of a heavily shielded transfer bell. Similarly, the handling of highly radioactive samples may require the use of a shielded sample pig. These shielding devices often have application-specific design requirements (e.g., bottom loading, under water loading, remote handling). The design and fabrication of these devices can be somewhat involved and therefore need to be initiated early on in the project.

Engineering/Design Indicators of Significance

Shielding design is not likely to require detailed engineering/design deliverables for the baseline unless there are large areas, high dose rates, and complex configurations that require shielding. An example of this exception is where a highly radioactive reactor vessel and internals are to be removed and transported for waste disposal.

If neutrons are the source to be shielded, the engineering/design experience base is more limited than for gamma radiation and the shielding materials are different. Special attention is appropriate.

Concept Development

Shielding design at the conceptual stage involve determining the source radionuclides and strength, their configuration and distribution, identifying the area to be protected, and stating the allowable dose rate at the location of interest. Calculations are conducted (e.g., with MicroShield™ for gamma shielding) to select the shielding materials and dimensions. Trade studies are conducted to evaluate options (example, steel vs. lead).

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Development of Baseline

With the information from conceptual calculations, the shielding configuration is designed to fit in the area of interest. Decisions are made as to whether shielding needs to be fixed and/or fabricated, or if "portable" shields such as sheet lead or bagged lead shot can be used. Deliverables include drawings or sketches for fabrication and installation. Shielding material (concrete, steel, lead, sand, and/or water) to be used is specified.

Except in exceptional cases indicted in the significance discussion above, initial baseline support only requires a need to understand the overall scope of shielding that will be needed for the project.

Ready for Implementation

Final design deliverables are completion of the above and procurement specifications for materials, equipment, and services.

Activity #18 Building Structural Integrity

This activity:

- Verifies that D&D activities will not adversely impact the building structure.
- Plans removal and/or modification of structures.

Description

The structural integrity of buildings undergoing D&D is a continuing concern for reasons of the potential for worker injury, storm water in-leakage, inadvertent collapse, or transport of contaminants to the environment.

Possible Variations

The structural analysis may also address impacts from D&D activities (e.g., noise, vibration, dust, structural interfaces) on surrounding structures, as well as the impact of removing sub-grade structures (e.g., foundations) on the stability of grades and slopes. An early understanding of potential issues is necessary since this may influence demolition approach. Timing is also important to allow stop-gap measures to be devised and their implementation appropriately built into the project schedule.

Engineering/Design Indicators of Significance

Building structural integrity is likely to be a significant engineering/design element of a demolition project. It is also of significance for other D&D activities when a facility is degraded.

Concept Development

Building structural integrity is assessed to support a variety of project activities and when.

- Degraded walls, floors, and/or walls present hazards to workers.
- Interior walls are removed to facilitate D&D activities.
- Demolition is in close proximity to or where there are connections to adjacent structures.
- Demolition potentially creates an airborne material hazard.
- Removal of the facility must be by disassembly and not conventional demolition.
- Removal of the facility has the potential to destabilize the area around its foundation.

At the conceptual stage of engineering assessment, the scope and reasons for analyses are stated. Characterization information is collected as needed to provide input to the analyses. This information can include visual and photographic inspections, dimensional verification, review of construction drawings, and in some cases intrusive (core drilling) or non-intrusive (ultrasound) verification of construction.

Deliverables during concept development are input to subsequent analyses.

Development of Baseline

Prior to implementation in the field, the analyses and evaluations are important for the following:

- The overall structural integrity of the facility needs to be evaluated as part of the initial facility condition assessment (Activity #7).
- Planned D&D activities that may impact structural integrity; in particular, planning for demolishing a building must be evaluated to develop a sequence that ensures premature collapse will not occur (Activity #36, Demolition Method and Sequence).

Other assessments conducted during implementation include:

- Once the facility is occupied by the D&D work force, building structural integrity must be periodically reviewed to confirm there has been no degradation of integrity due to environmental conditions or D&D activities.
- As work progresses, the need to remove process equipment may necessitate building structural modifications, such as removing or making openings in walls and roofs. Loadings on structural members as a result of rigging and transporting heavy equipment items for removal and disposal must also be evaluated.

Analyses are conducted such as for floor and roof loading, temporary supports, reinforcement of remaining structures and surrounding features, seismic stability of remaining structures, attachment of new guard rails and lifelines, removal of load bearing walls, and sequence of building demolition to prevent premature collapse. Analyses are documented with results of calculations and recommendations such as sequence of removal and the need for modification or reinforcement to support D&D operations.

Design structural modifications include deliverables such as new and marked up existing drawings (e.g., arrangements), loading diagrams, component selection (e.g., deck plate, jack posts), and choice of materials (e.g., type of steel, structural shapes).

Ready for Implementation

Engineering includes completion of design for structural modifications. Deliverables include final drawings and procurement specifications for materials, equipment, and services.

Activity #19 Temporary Electrical Service

This activity provides electrical power for lighting, tools, and equipment when installed circuits are de-energized.

Description

When a facility is isolated from all design power to ensure the facility is safe for D&D activities, temporary electrical power is provided for the limited needs of workers, such as for lighting, power tools, added local ventilation, pumps, compressors, and the like.

Cases to be considered include:

- Additional power sources are needed at locations within a facility to support power tool activities such as size reduction, decontamination, applying fixative, and others. An example of how this accomplished is with power supplies mounted on wheels that are powered from 480-volt welding receptacles within the facility. Another example is the use of industrial quality extension cords that are affixed in the overhead between the source and the location where needed.
- An entire facility is de-energized to ensure there are no power sources from within the facility to allow workers to safely make line breaks and cut conductors without having to implement lockout/tag out procedures for each activity. However, since electrical power is still needed for lighting and power tools to support D&D operations, low cost temporary distribution panels are typically installed where needed to feed string lighting and power distribution cords. These are clearly identified as the only energized systems in the facility. Due to their low cost, the strings and cords are often abandoned in place until final disposition of the facility

Engineering/Design Indicators of Significance

Temporary electrical supply is not likely to require detailed engineering/design deliverables for the baseline because the scope is usually not large and methods are conventional.

Concept Development

Identify the number locations and the magnitude of temporary power needed to support D&D operations.

Development of Baseline

Engineering/design activities include:

- Identify the power needs based on an estimate of locations and the loads voltage and amperage.
- Specify how power will be safely distributed to the areas needed. Specify number and location of temporary distribution panels. Determine lengths of string lighting and power cords required. Specify method of providing power to temporary distribution panels.
- Perform analysis to ensure that the total load does not exceed source capability, such as at a distribution panel.
- Design deliverables such as power circuit drawings, terminal drawings, instrument and control diagrams, and portable connection modules.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete design of temporary electrical system and engineering packages for installation. Provide procurement specifications for materials, equipment, and services.

Activity #20 Replacement Electrical

This activity provides electrical power when installed circuits are to be isolated.

Description

In some cases, a limited set of equipment (e.g., ventilation system, overhead cranes, and pumps) must be maintained during D&D activities. Design and installation of dedicated new electrical supply equipment to power the critical load(s) may be required. This will provide high confidence that all the other equipment has been de-energized and can be safely removed.

In some situations, particularly in large and complex facilities that may be placed in an extended period of S&M, it is advantageous to install new electrical distribution equipment to power a reduced set of key loads that will remain energized during D&D operations and possibly a subsequent S&M period. This will allow the original system to be deactivated and possibly removed.

Engineering/Design Indicators of Significance

Replacement electrical supply is not likely to require detailed engineering/design deliverables for the baseline because design and cost estimation of electrical systems is well understood in the construction industry.

An exception is when an entire facility is to be re-powered external to the installed distribution system.

Concept Development

Evaluate the need for replacement electrical systems. Compare the cost-benefit of installing a reduced capacity replacement system dedicated to limited number of key loads and determine if feasible.

Development of Baseline

Develop preliminary design of the replacement electrical distribution system in sufficient detail to establish a high confidence project baseline.

Ready for Implementation

Complete design of replacement electrical system, including required drawings. Complete detailed procurement specifications.

Activity #21 Ventilation Modifications

This activity maintains contamination control as ventilation systems are reconfigured.

Description

Deactivation of facilities and preparation for demolition can require isolating portions of and/or reconfiguring a facility's ventilation scheme. It is essential to maintain confinement zones within the facility by controlling zone pressure such that air flows from low contamination zones to high. This will require modifying procedures and operating modes, and re-balancing of air flows as equipment is deactivated.

Two key reasons for modification and/or reconfiguration of the installed ventilation systems are:

- Many buildings in the DOE complex rely on active exhaust ventilation for contamination control. Deactivating such buildings where all contamination cannot be removed or locked down with fixatives creates a need to maintain a sub-atmospheric internal pressure and exhaust flow through filters. In such cases exhaust systems and stacks, including flow and radioactivity monitoring instruments, must remain operational during and after deactivation. The flow rate requirements may be reduced in some of these cases because all process operations have been discontinued; for example, by operating fewer exhaust fans than were needed during operation.

- As components are isolated from a contaminated exhaust system, the system flows and flow distribution will vary from the design flow balance on the remaining components. Too-high negative pressure may create too high flow rates through individual components such as gloveboxes, exert extra pressure on gloves, or make it difficult to open and close component air locks.

In the latter case, because balancing ventilation flows is as much an art as it is a science, there may be no choice other than to re-balance as equipment isolation occurs. In such cases, the engineering support for these activities will necessarily take place during implementation.

Engineering/Design Indicators of Significance

Ventilation modifications are not likely to require detailed engineering/design deliverables for the baseline unless:

- The facility has more than a few gloveboxes, hoods, lab benches, process operations, or rooms with surface contamination

- There is more than one ventilation system for contaminated zones, or if flow is cascaded from a lesser contaminated zone to a higher one, or if there is one system which serves many areas

Concept Development

The overall scheme for modifying ventilation systems should be addressed at a functional level for all systems in the facility considering the project's work progression and the facility's eventual end state. Air permits and other regulatory approvals related to stack exhaust, and their need for modification, should be identified.

Development of Baseline

Baseline development has two components:

- Engineering evaluations should be conducted to support decision regarding the configuration of the facility exhaust system. To the extent that design changes are needed, related drawings and other documents should be produced at a level of detail sufficient for physical modifications.

- With regard to balancing flows and exhaust system adjustments to accommodate component isolation, baseline development is estimating the engineering effort needed during conduct of the project.

It should be understood that details of how to modify or rebalance the ventilation cannot be specified prior to CD-3 because doing so is highly dependent on the sequence in which components are taken out of service or when walls are modified for access. The sequence and timing of such work changes frequently in real time during implementation.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Engineering deliverables for implementation include:

- Completion of designs initiated for system modifications.
- Technical requirements for procedures and work packages.
- Procurement specifications for materials, equipment, and services.

Activity #22 Temporary Ventilation

This activity supports contamination control and in some cases improves habitability conditions for workers.

Description

The primary reason for temporary ventilation in support of D&D efforts is for contamination control. Another application is to improve habitability conditions for workers, especially where heat stress is a potential problem.

The design of temporary ventilation systems for contamination control needs to be such that air flow is from clean areas to areas of moderate contamination, to areas of high contamination, and finally to an exhaust system capable of removing any contamination from the air. Slight negative pressure is maintained in buildings/rooms/enclosures where potential contamination exists.

Local area operations such as surface decontamination, size reduction, equipment reconfiguration, and other such activities may require contamination control using local ventilation exhaust systems with HEPA filtration to augment the permanent installation. Additional needs may be for purging of stagnant spaces or temperature control for worker comfort.

This represents a case in which a comprehensive package is required, contrasted with small-scale off-the-shelf exhausters. Engineering includes design, equipment selection, configuration, specification, and other functions typical of new equipment installation. In addition, the fact that it is not permanent may require special considerations such as power sources and connection to a facility's installed exhaust system.

Some D&D projects may have skid-mounted or portable units already available, in which case much of the information needed to support a baseline will be available with minimal engineering.

Engineering/Design Indicators of Significance

Temporary ventilation is not likely to require detailed engineering/design deliverables for the baseline unless:

The need for temporary ventilation automatically implies existence of airborne hazards that must be controlled

If the project has extensive ventilation needs and requires several temporary systems or a large single system, the design, fabrication/installation activities could be rather involved.

Concept Development

Identify the activities/areas and contamination levels associated with these activities/areas that will require temporary ventilation, and the ventilation system configuration to satisfy these needs.

Development of Baseline

Evaluate and specify the ventilation requirements, including:

- Ventilation airflow/ CFM requirements
- Building air pressure requirements (usually negative air pressure)
- Number of air changes per hour
- Temporary/point source ventilation requirements
- Ventilation balancing requirements (with rest of building)
- HEPA requirements (DOE approved filters and enclosure)

Determine temporary ventilation approach (i.e., air mover with (HEPA) filters, fans, etc. or HVAC system; packaged unit or custom assembled); and determine needs for temporary enclosure, tent, barriers, etc.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Engineering deliverables include:

- Work sequence/installation instructions
- Informational photos and drawings
- Electrical wiring diagrams
- Rigging configuration and requirements
- System/components to be installed and locations
- Post installation testing requirements
- Procurement specifications for materials, equipment, and services (if required)

Activity #23 Breathing Air

This activity provides supplied air when required for respiratory protection.

Description

As a result of electrical isolation of the facility or system disrepair, the facility's breathing air compressor system may not be available. The need for a temporary air supply and distribution system to support D&D activities must be evaluated. If needed, it must be designed and specified. Breathing air requirements are project specific, depending on nature of the radiological and chemical contamination in the facility, including its potential to become airborne during D&D operations. Portable systems are typically needed.

Engineering/Design Indicators of Significance

Breathing air is not likely to require detailed engineering/design deliverables for the baseline because its scope is typically limited and it is a well understood activity.

Concept Development

Identify the need for breathing air during D&D operations by considering the likelihood of success of methods (e.g., decontamination, application of fixatives, etc.) to reduce airborne contamination during D&D. Identify locations and needed capacity if evaluation by radiological engineering and/or industrial hygiene personnel indicate that breathing is required for personnel protection.

Development of Baseline

Develop preliminary design of the breathing air distribution system in sufficient detail to establish a high confidence project baseline.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete design of breathing air system. Deliverables include drawings, sketches, and calculations. Provide procurement specifications for materials, equipment, and services.

Activity #24 Temporary Enclosures and Containments

This activity provides enclosures when required for contamination control or concealing equipment.

Description

Design and specify temporary structures when needed to provide contaminant confinement during decontamination, size reduction, equipment removal, etc. Temporary enclosures also allow use of un-cleared workers in vicinity by preventing visual access and/or isolation of classified equipment.

Temporary enclosures may include, but not limited to:

- Soft sided enclosures – thermoplastic (Vinyl, PVC, other) containment tents designed in-house or procured from commercial vendor.
- Rigid enclosures – plywood, wood, metal and other rigid enclosures designed in-house or procured from commercial vendor.
- Modular enclosures procured commercially.

Temporary enclosure design for contamination controls is always conducted together with ventilation design. Challenges for temporary enclosure design are containing airborne alpha radioactivity or isotopic species that are especially onerous (e.g., Pu-238), and high concentrations of beta-gamma contamination.

Engineering/Design Indicators of Significance

Design of temporary enclosures is not likely to require detailed engineering/design deliverables for the baseline unless there is a need for a very large enclosure (e.g., to enclose a building) or the project requires a large number of individual enclosures.

Concept Development

Several different approaches may be taken to provide temporary enclosures to control, contain, or isolate radiological contamination, hazardous material, or fugitive dust. Design of facilities should be such that efficiency of maintenance, operations, and decontamination is maximized. Include support facilities that provide for donning and doffing of protective clothing and for personnel monitoring.

Temporary ventilation will probably be required, which is addressed as a separate engineering task. Information provided at the conceptual stage is to identify the activities/areas, configuration and contamination levels requiring temporary enclosures.

Development of Baseline

The on-site availability of specialty shops or organizations that fabricate enclosures, or the use of third party vendors to provide them will need to be considered during baseline development.

Initial engineering to support baseline review includes:

- Evaluating temporary enclosure needs (number, type, size). This evaluation is augmented by photos, sketches and/or drawings of location(s) where the enclosures will be placed and how they are to be physically supported if not self-standing.
- Recommending the types of enclosure; for example, for a tent, whether it is a simple chamber tents or has multifaceted requirements such as expandable and multi-tier, multi-chamber tents.
- Determining ventilation constraints and requirements to support selections regarding the type of enclosure.

For cases of a relatively large engineered enclosure that represents a significant cost, engineering to support baseline development should include:

- Specifying design requirements including size, characteristics, and boundaries

- Enclosure configuration and contamination control techniques
- Calculations, specifications, and drawings
- Informational photos at the installation location
- Engineering/design for structures, electrical supply, and ventilation system
- Engineering/design of equipment and components

For small or simple enclosures, this engineering/design can be done after CD-3.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Each use of a temporary enclosure needs to be identified in a detailed work package, whether it is a stand-alone temporary enclosure package or is combined with a larger D&D work package. Package development includes the following:

- Installation test requirements
- Operations test requirements
- Details of technical requirements that must be included in creating work packages and operating procedures
- Procurement specifications for materials, equipment, and services.

As above, for small or simple enclosures this engineering can be done after CD-3.

Activity #25 Hazards Analysis

This activity ensures worker safety.

Description

Address potential non-radiological hazards resulting from prevailing conditions and materials within the building, and from work activities associated with the D&D scope. This analysis focuses on the industrial safety and industrial hygiene aspects of the field work and serves as the basis for physical and administrative controls to protect the health and safety of workers, equipment, and the environment; identifies safety hold points; and lists health and safety requirements for subcontractors and site personnel working in the field.

D&D projects entail many activities that represent significant safety challenges; as such, emphasis needs to be placed on ensuring worker safety. Most sites have a cadre of dedicated professional staff and procedures related to safe work practices, and it is standard practice to follow these for work activities (including D&D projects) at the site. In some instances, D&D projects may involve conditions or entail activities that are not addressed in existing procedures. These conditions will need to be addressed on a case-by-case basis.

Engineering/Design Indicators of Significance

Hazard analysis is not likely to require detailed engineering/design deliverables for the baseline because conducting such analyses is routine practice for all field work activities and is a fairly understood process, unless:

- The project scope involves a complex facility with large amounts of process equipment, which typically presents numerous industrial type hazards, or
- There is a confirmed presence of hazardous or toxic materials (such as beryllium), or
- The structure is in a severe condition of disrepair thus presenting an unsafe work environment, or
- The proposed work approach requires a large amount of PPE.

Concept Development

It is customary to perform a preliminary hazard analysis to identify potential safety issues because of prevailing conditions and materials within the building(s) in the D&D scope. The preliminary hazards analysis should also address potential safety issues from work activities associated with the D&D scope. The findings of the preliminary hazards analysis should be documented in a report.

The hazards analysis report should identify which standard procedures apply to the project and identify any unusual or unique conditions that will require personnel protection not addressed in existing procedures.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Development of Baseline

Based on the preliminary hazard analysis, specify the control and mitigation activities (i.e., lead dust vacuuming, beryllium abatement, mold mitigation, etc.) that will be required for the project scope. These activities will typically be discrete tasks in the baseline.

In addition, specify the incremental material, equipment, and costs associated with the safety protocol (i.e., fall protection, LO/TO, confined space entry, etc., which is typically addressed in existing procedures) that will required for the project scope.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for control and mitigation activities as specified above, and PPE requirements not otherwise addressed in standard procedures
- Procurement specifications for materials, equipment, and services

Activity #26 Hazardous Material Abatement

The purpose of this activity is to remove non-radiological material hazards for reasons of:

- Personnel health and safety
- Environmental protection
- Disposal WAC related to generation of mixed waste

Description

Facilities being transitioned to D&D are typically old and may have been poorly maintained prior to transition. The presence of water and lack of ventilation can lead to growth of mold. Due to their age, these facilities also often have asbestos-containing materials (ACM) of construction. Materials hazardous to worker health, such as beryllium, may also be present as a result of facility mission. These hazards must be abated, usually early during in the facility D&D project.

Asbestos is by far the most prolific hazardous material encountered in excess facilities. It exists as flooring and/or ceiling tiles, Transite siding, roofing materials, wallboard joint compound, window glazing, electrical wire insulation, and pipe lagging. The current practice is to completely remove all ACM from a facility prior to full-scale demolition. Some cases for which open air demolition of asbestos-containing roofing have been allowed because the hazard to workers on an old roof was judged as unsafe.

Engineering/Design Indicators of Significance

Hazardous material abatement is not likely to require detailed engineering/design deliverables for the baseline unless:

- The facility contains large quantities of hazardous or toxic materials
- The facility contains hazardous or toxic materials in elevated locations (e.g., Transite siding on multi-story structures),

Concept Development

Identify the presence of hazardous materials and the need for abatement. These tie in with the hazard analysis discussed in Activity #25. Identify special equipment to be designed or procured because of unusual or unique hazards.

Development of Baseline

Based of the findings of the preliminary hazards analysis, a quantification of the amount of hazardous materials present and the extent of removal/abatement that will be required is needed to establish a baseline. Specify the quantity of material to be removed, removal/abatement methods, number and size of abatement crews, equipment required (i.e., fork lifts, man-lifts, HEPA vacuums, power washers, etc.), and containments. Design or provide design input to special equipment if needed.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers and project team that will be conducting the activity.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for the abatement activities, PPE requirements, containments, and preparation of abatement waste for disposal
- Procurement specifications for materials, equipment, and services

Activity #27 Liquid Waste Management

This activity identifies sources of liquid waste in the facility and plan for their disposal.

Description

Liquids are likely to be encountered in sumps, piping, vessels and other equipment. Typical liquids encountered include water, aqueous solutions of chemicals, and organics such as oils and solvents. Small quantities drained from or found in equipment can typically be adsorbed using appropriate commercial products and disposed with the equipment. For large volumes, an appropriate treatment, disposal, or storage facility must be identified. Methods to drain, collect, and transport the liquids must also be identified.

If bulk liquids are at a facility, to the degree possible they should be removed relatively early in the D&D project to take advantage of operational staff that know the facility. This is especially the case for process chemicals such as acids and organic; and for contaminated water.

Possible Variations

Liquid waste management may also include addressing the intrusion of surface and/or groundwater into the building structure, generally in the form of a flooded basement. In these cases it may be necessary to devise an overall water management strategy that identifies and (if possible) controls the source, selects the method to remove the water, and establishes the treatment requirements. Management of surface and/or groundwater intrusion into the building footprint after the building has been demolished and removed is addressed in Activity # 38.

Engineering/Design Indicators of Significance

Liquid waste management is not likely to require detailed engineering/design deliverables for the baseline because this is a fairly standard and routine waste management activity.

Exceptions are in cases when:

- There are large volumes of contaminated water.
- The site has no liquid waste management capabilities.
- There are extensive process systems that contained acids, caustics, reactive, flammable, oily, or radioactive liquids and these systems may not have been completely drained.

Concept Development

Identify potential sources of liquid waste; estimate quantities; determine characteristics of each source to enable determination of disposition pathway. Also, identify the most likely processing and/or disposition paths. Address whether processing will be conducted with in-plant systems, vendor supplied transportable units, or facilities elsewhere on-site, and whether any bulk transport is needed.

Development of Baseline

Engineer and/or specify the methods to manage (i.e., collect, package, transport, process, etc.) liquid wastes. Do the same for treatment methods. For on-site treatment, design or provide engineering input to specifications of treatment equipment.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Provide detailed design of on-site treatment system, and collection and transport equipment. Provide procedures for liquid waste collection, packaging, transport, and processing.

Activity #28 Waste Identification & Planning

This activity identifies and quantifies all solid wastes to be generated during the project.

Description

Waste handling and disposal are major components of a D&D project's baseline scope, cost, and schedule.

Considerable planning must be done early in the project's conceptual phase to identify and quantify the types of waste that will be generated. The volumes of sanitary, low level, hazardous, mixed, transuranic, and possibly high level waste are likely to be substantial. Treatment, storage and disposal facilities must be identified and plans for waste transport to these facilities must be developed. In addition to the actual material from the demolished or removed SSC, job-added waste including PPE, discarded tools, secondary waste from decontamination and size reduction activities, containments, and temporary structures must be accounted for in the waste management planning. Depending on the scope of the D&D project, this could represent a significant amount of additional waste.

Excess facilities often become the "home" for discarded equipment and unpackaged waste items. These legacy items require disposition and by default may become part of the D&D project scope. Planning for their disposition may pose a challenge since documentation is often sketchy, at best.

Engineering/Design Indicators of Significance

Waste identification & planning is likely to be a significant engineering/design element of the project because most D&D projects generate significant quantities and many types of waste.

Concept Development

Characterization data (see Activity #8) will be required to support disposition planning. Identify:

- All waste streams anticipated from the D&D project scope and provide quantity estimates for each waste type.
- A disposition pathway (including transport mode and disposal destination) for every waste stream.
- Packaging and processing to meet transportation regulations and disposal facility WAC.
- The type and quantity of orphan wastes present (i.e., without a disposition pathway), if any.

Development of Baseline

A comprehensive waste management plan should be created to address all project tasks for dispositioning all waste types (both newly generated and legacy) to be encountered in the project. The waste management plan includes:

- Comprehensive listing of projected quantities by physical, radiological, and chemical characteristics.
- Tradeoff studies, such as for disposal location options.
- Generation rates and schedules.
- Identifying transport mode and disposal destination for every waste type, including shipping container needs.
- Identifying packaging configuration for every anticipated waste type and related equipment and consumables.
- Conditioning to meet transportation regulations and disposal site WAC.

- Waste minimization efforts to minimize "job added" waste and avoid generation of any wastes that do not have a disposition pathway.

Ready for Implementation

Implementation development includes:

- Revised project baseline resulting from new information (i.e., characterization data), revised assumptions, and/or more clearly defined approach to project work activities
- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for management of all waste types to be generated
- Procurement specifications for materials, equipment, and services

Activity #29 Waste Conditioning & Packaging

This activity addresses packaging configurations and necessary processing to satisfy both transportation requirements and disposal WAC.

Description

All waste generated by the project must be packaged and (possibly) conditioned to meet shipping regulations and disposal facility WAC.

Depending on the type(s) and characteristics of the waste generated by D&D activities, processing or conditioning may be required to prepare it for packaging to meet transportation regulations and disposal site WAC. The final waste characteristics must consider:

- Waste form/stability
- No free liquids
- Size restrictions
- Radionuclide concentration
- Void fraction (i.e., for piping)
- Volume reduction

Some examples of waste conditioning include:

- Grouting of components to fill void space and/or waste stabilization to meet disposal WAC.
- Addition of vermiculite to absorb liquid heels in tanks and process vessels.
- Crushing medium-bore piping therby eliminating void space to address subsidance concerns in burial grounds.

Past experience has shown that it is generally not economically feasible to decontaminate materials for free-release. However, certain economic advantages may be realized by decontaminating items to lower their waste classification. For example, decontaminating a glovebox to less than 100 nCi/g TRU to allow disposal as LLW eliminates the need to size reduce the glovebox (a very labor intensive endeavor) for packing into standard waste boxes (SWBs) for disposal at WIPP.

Engineering/Design Indicators of Significance

Waste conditioning & packaging is not likely to require detailed engineering/design deliverables for the baseline because this is a fairly standard and routine waste management activity.

Exceptions are in cases when:

- The project will generate waste with high radiation levels, is TRU, or is high level waste that will require special handling and packaging.
- The waste generated by the project will require complex processing (i.e., require many steps).
- The project will generate large quantities of waste that will require conditioning prior to disposal.

Concept Development

Evaluate waste conditioning and packaging needs and alternatives suitable for anticipated waste types. Identify waste certification requirements.

Development of Baseline

Specify packaging configuration for every anticipated waste type and any conditioning required to meet transportation regulations and disposal site WAC. Specify waste certification steps and technical compliance methods. Provide engineering and preliminary design of special packaging when needed and specifications for equipment and services procurement.

Note that this activity may be conducted with Activity #28, Waste Identification and Planning.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including functional and performance specifications for waste processing/conditioning, and for waste packaging and certification
- The final design of any required special packaging
- Conduct certification, when needed
- Estimate of waste packages and packaging consumables needed
- Procurement specifications for materials, equipment, and services

Activity #30 Waste Staging

This activity ensures sufficient storage is available for waste management and supports the logistics of container management.

Description

Since loading waste into containers is a major D&D project activity, empty containers must be continuously available at waste loading locations. Conveniently located space must be provided for staging both empty and full containers. The quantity of appropriate types of containers must be identified and equipment to move them from the staging areas to loading locations must be provided.

Convenient and adequate buffer storage is necessary to support D&D activities to maintain schedule efficiency and to decouple waste management activities from becoming critical path for D&D activities. The ideal location should be close to the facility undergoing D&D to minimize waste transport distance; but it should be out of the way enough to minimize congestion.

Some cases require modifications to facilities to enable use of spaces for storage. Examples include widening openings, means of spreading floor loading, and installing handling equipment. (Structural modifications are addressed in Activity #18).

Engineering/Design Indicators of Significance

Waste staging is not likely to require detailed engineering/design deliverables for the baseline because this is a standard and routine waste management activity, unless:

- The project will generate waste with high radiation levels, or is TRU, or is high level waste that will require special handling and special provisions for staging (e.g., shielding, safeguards & security, or criticality control), or
- The project will generate large quantities of waste that will require staging.

Concept Development

Based on waste generation forecasts (as determined in Activity #28), evaluate waste staging needs and capacity requirements. Identify suitable locations that will support D&D activities.

Development of Baseline

Engineer, design as needed, and specify waste staging location and features required to support waste staging activities (i.e., security fencing, video surveillance, radiation/criticality monitoring, weather protection, fire detection/suppression, etc.). Also, specify material handling requirements (i.e., forklifts, cranes, hand trucks, etc.).

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for the final design of the above along with material handling and waste staging requirements
- Procurement specifications for materials, equipment, and services

Activity #31 Waste Transport & Disposal

This activity complies with shipping regulations and disposal WAC.

Description

Identify disposition destination and transport methods for all waste types. Waste transportation and disposal represent a significant portion of the total project cost.

D&D projects result in the generation of industrial, hazardous, and radioactive waste, and scrap/salvage materials; and depending on the complexity of the project, the quantity of these items could be very significant. Planning for their disposition can be complex because of such factors as the variability in waste constituents, limited choice of disposal sites, landfill regulations that apply to other than radioactive waste, transport restrictions through local communities, the DOE metals moratorium (for materials that otherwise would not have to be disposed as waste), and other factors.

With regard to waste transport and disposal, the key issues to be addressed include decision to utilize government versus commercial disposal; on-site versus off-site disposal; truck versus rail transport. Cost-benefit analyses are vital to the decision process. Consideration must also be given to disposal facility certification requirements, which can require significant resource commitment (See Activity #9).

Possible Variations

Waste transport and disposal may include shipping cask design/modifications. Some waste streams from D&D projects (either legacy materials or newly generated waste) may be of a size or shape, or have radiation levels, or be classified, such that they cannot be accommodated by existing shipping casks. In such cases physical design (or licensing) modifications to existing casks may be required; or the design (and certification) of a completely new cask may be required. In either case, the activities associated with shipping cask design and certification are rather complex and will require considerable engineering/design input and may be best if treated as a separate project.

Engineering/Design Indicators of Significance

Waste transport and disposal is not likely to require detailed engineering/design deliverables for the baseline because this is a fairly standard and routine waste management activity.

Exceptions are in cases when:

- The project will generate large quantities of any type of waste therefore requiring numerous shipments to disposal sites.
- The project involves shipments of TRU waste or any shipments that require special shielded shipping casks.
- The project involves the shipment of classified materials, thus requiring Q-Cleared drivers.
- Scheduling logistics are complicated by the limited availability of containers/casks.

Concept Development

A definite disposition pathway (including transportation mode and disposal destination) needs to be identified for every waste stream identified in Activity #28. Evaluate the availability of suitable transport casks and disposal containers.

Development of Baseline

Based on cost-benefit analyses, specify the transport mode and disposal destination for each waste type/stream expected to be generated by the project. Provide an estimate of the number of shipments (i.e., truck loads or rail cars), and estimate of the quantity of waste to be dispositioned (either in terms of volume or number of containers by waste type). Specify any field staffing resources required to support waste transport and disposal.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

The final design should include a revised estimate of the number of shipments and quantity of waste to be disposed. Specify the validation requirements necessary to ensure compliance with transportation regulations and disposal site WAC. A transportation management plan that outlines the logistics of shipment scheduling may be required for complex projects with a large number of waste shipments. Procurement specifications for materials, equipment, and services should also be provided.

Activity #32 Facility Isolation

This activity isolates a facility from all external utility systems.

Description

Prior to final decommissioning, whether it be by demolition or in-situ entombment, external service systems such as water, sewer, electrical, steam, gas, phone, etc., must be isolated in order to:

- Protect workers from energetic sources
- Allow continued service to other facilities in the area

Physical air gapping, as follows, is a way to ensure isolation:

- Electrical Air Gap – The cutting of a conductor, cable, or conduit so that it can be visually verified and cannot be easily reconnected. This requires the removal of enough of the conductor, cable, or conduit to require rewiring to reconnect. Lifting and taping of leads, removing fuses, and opening disconnects do not qualify as physical air gaps.
- Mechanical Air Gap – The cutting of piping or tubing so that it can be visually verified as empty and un-pressurized. This requires the removal of enough of the piping or tubing to require major re-work to connect. For large diameter piping, it is acceptable to cut or drill multiple holes into the pipe and not remove a complete section of the pipe. The closing of a valve or installation of a pancake does not qualify as a physical air gap.

Engineering/Design Indicators of Significance

Facility isolation is not likely to require detailed engineering/design deliverables for the baseline unless the facility is highly complex and has large number of service systems, particularly if they are underground and their location is not well documented.

Concept Development

Perform facility walkdown and drawing review to identify utility system penetrations through floors, walls, and roof.

Development of Baseline

Identify the external source or destination of all penetrations. Determine isolation point, draining controls, and air gap criteria. Prepare sketches and take photographs to aid in documentation. Develop detailed index of all electrical and mechanical isolation points. Specify isolation methods.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project’s engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete design. Complete procurement specifications for materials, equipment, and services.

Activity #33 Temporary Roads and Access Ways for Heavy D&D Equipment

This activity prepares the site for the mobilization of heavy equipment needed for D&D.

Description

Heavy equipment such as cranes, excavators, track-mounted shears, and hydraulic hammers may be required during facility D&D. Temporary roads to allow this equipment to get into the position to perform its function may be required. This activity also includes design and installation of ramps and special pads for deployment of equipment to reach high structures. The activity may also include design and installation of rail spurs if needed.

This is a conventional civil design activity. Temporary rail spurs may be needed if rail transportation is the best or perhaps the only method to transport waste to the appropriate treatment, storage and disposal facility. In some cases, it may be desirable to build a temporary road from the facility to the waste disposal site.

Engineering/Design Indicators of Significance

Temporary civil works is not likely to require detailed engineering/design deliverables for the baseline because its scope is typically limited and it is a well understood activity.

Concept Development

Identify the areas where temporary roads and access ways will be needed by considering what type of heavy equipment will be required for D&D and where it will be deployed.

Development of Baseline

Develop road and access design sufficient for high confidence project baseline. Estimate total feet of roadway, guardrails, ramps, curb and gutter, sidewalk work, storm drains, large culverts, lighting, and bridge work. Estimate cost from unit cost factors.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete final design drawings if required. Provide procurement specifications for materials, equipment, and services.

Activity #34 Temporary Water for D&D

This activity provides water when needed for D&D activities.

Description

Facilities undergoing D&D may be isolated from permanent water supply; a temporary source of service water may be required for the following applications:

- Suppression of dust generated by vehicle movement
- Dust suppression during structure demolition (for chemically or radiologically contaminated facilities, this is a contamination control issue)
- Equipment washing

This water need not be potable.

Engineering/Design Indicators of Significance

Temporary water is not likely to require detailed engineering/design deliverables for the baseline because its scope is typically limited and it is a well understood activity.

Concept Development

Identify the need for temporary water. Evaluate alternatives for water supply (e.g., tanker truck, temporary water line from nearby facilities, etc.). Select optimum alternative.

Development of Baseline

If temporary facilities are required to support water supply, develop design to level of detail for a high confidence baseline. If water is to be provided by tanker, estimate volume of water needed and number of tankers needed.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Provide procurement specifications for materials, equipment, and services.

Activity #35 Completion Verification Survey

This activity verifies that the decommissioning endpoints have been met with regard to residual contamination.

Description

Final verification typically requires a survey of both fixed and removable contamination using a defensible methodology, such as defined in NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).

Final verification surveys often require sampling of remaining media to various depths and lab analysis of the samples for the constituents of concern. In order to have statistically valid results, many samples may be required. Since lab analysis of these samples may be expensive, the total cost of performing the final verification may be significant.

Engineering/Design Indicators of Significance

This activity is not likely to require detailed engineering/design deliverables for the baseline because the method and protocols for such surveys are well established.

Concept Development

Identify the need for a final verification survey based on the D&D alternative selected and a preliminary understanding of the contaminants present in the facility.

Development of Baseline

The contribution of this activity to the project cost baseline must be determined by estimating the number of final verification samples to be taken and their expected unit cost. As discussed above, this cost is likely to be significant for large contaminated facilities. This activity cannot be completed until after demolition. Duration of several months may be required for sampling, lab analysis of the samples, data interpretation, and final report preparation.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

The activity requires development of a final verification plan. This plan may include or reference a statistically based sample plan, which identifies sample locations. The contents of these plans are used to develop detailed work packages, which will be executed after the final decommissioning end points are ready for verification. Typically, the results of the end points verification are documented in a final verification report. If the survey and/or sampling indicate that the end points have not been met, additional decontamination is performed until they are achieved.

Activity #36 Demolition Method and Sequence

This activity establishes a preferred demolition method.

Description

Demolition of excess facilities is accomplished either by a conventional "wrecking ball" approach or by "surgical dismantlement." Selection of a demolition approach is influenced by factors such as noise, dust, and vibration interferences with adjoining or adjacent facilities; structure size/configuration; construction style and materials; and level and type of contamination.

Structural aspects include component and equipment removal sequence, specifying the starting location, direction in which work will progress, and plans for dealing with interferences. A structural analysis may be required to support selection of demolition method and component removal sequencing. Simple one or two story structures that are fairly isolated from surrounding structures can be demolished with track-mounted excavators fitted with a hydraulic shear.

Multi-story complex structures, and structures located in close proximity to other structures that will remain operational must be demolished in a more controlled manner. Special attention will be needed in these situations and a structural analysis is usually needed for the demolition plan.

Possible Variations

Building demolition may involve hot cell structures. D&D of hot cells pose many challenges due to the high contamination typically contained within, limited accessibility, visual obstruction, and the occasional unusual (i.e., high radiation level) legacy items left within. Design considerations include overcoming characterization challenges (i.e., with remote technologies), contamination control by aerosol fog or spray fixative; addressing structural issues (hot cells components may be integral to the overall building structure), demolition method (i.e., diamond wire saw, concrete nibbler, pneumatic hammer, etc.), and handling of the dedicated ventilation system.

Engineering/Design Indicators of Significance

Demolition method and sequence is likely to be a significant engineering/design element of the project because one or more of the following conditions will usually exist for the structure(s) to be demolished:

- Is in a state of disrepair thereby presenting worker safety issues due to structural instability.
- Contains contamination.
- Is a large multi-story and/or very robust structure.
- Is located in close proximity or connected to a facility that is to remain operational.

Concept Development

Identify the method(s) by which demolition will be conducted, including:

- Demolition method (conventional with excavators, "surgical" dismantlement, implosion, or advanced (e.g., harmonic delamination, which is the use of a large number of very small explosive charges to separate concrete from rebar).
- Need for remote tools and techniques.
- The required tools and equipment for demolition (e.g., cranes, excavators, excavator attachments, saws, thermal cutting tools, special rigging).

Determine if a structural analysis is required to support safe building demolition. Also, determine the minimum space/zone required for safe demolition of the structure including identifying interferences that must be taken into account. Determine the placement location of tools and demo equipment and the requirement for any structural modifications to support their placement.

Development of Baseline

Development of the baseline includes:

- Identifying points of potential failure (as determined in the structural analysis delineated in Activity #18) and specification of mitigation measures to support safe facility demolition.
- Engineering for structural component removal sequence (based on structural analysis). Deliverables include:
    - Work scope for demolition/dismantlement
    - Sequence of demolition/dismantlement actions when important to maintain stability of structure
    - Sketches depicting sequence
- Preparing a detailed demolition plan that includes the following:
    - Sequence of demolition/dismantlement actions
    - Identification of interferences and method(s) for safely dealing with them
    - The number of crews and crew size and required skill mix
    - Specification of equipment requirements (excavator with attachments, cranes, mechanical hand tools, hot tools)
    - Specification of any special equipment that may be required
    - Evaluation and specification of environmental controls (e.g., wind speed limitations), dust suppression methods, and containing rubble and debris. (Environmental controls for open air demolition are addressed in Activity #37).

Ready for Implementation

Implementation development includes:

- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for all required environmental controls, dust suppression, and rubble containment as needed, specification of required worker safety provisions (including PPE), and specifications for the demolition approach, steps, and sequence (i.e., the order in which particular structural members are removed/demolished).
- Listing of required equipment and tools.
- Procurement specifications for materials, equipment, and services.

Activity #37 Environmental Requirements and Controls for Open Air Demolition

This activity ensures that all required environmental analyses have been performed, regulatory permits obtained, and physical controls are in place and maintained during demolition.

Description

Identify the environmental controls required for mitigation and control of:

- Noise
- Vibrations
- Dust
- Contamination
- Storm water runoff
- Truck traffic

This also includes determination of the source term for dose modeling and the allowable meteorological conditions for open air demolition.

Dust generation should be controlled to prevent particulate transport to the environment during the demolition process, particularly for contaminated facilities. Simple water sprayers are usually sufficient. In some cases, it may be desirable to employ more sophisticated systems such as water cannons or foggers. These devices produce finer water droplets (often with the aid of surfactants mixed into the water) and distribute the water from a greater distance from the immediate point of dust generation where the demolition equipment is operating. In cases where there is concern about the possibility of particulates in debris piles becoming of airborne due to high winds, commercial products (e.g., an aqueous, acrylic-vinyl-acetate emulsion which polymerizes on contact with air has been shown to be effective in immobilizing particulates.

Possible Variations

A recent development within the D&D community is the open-air demolition of structures with certain types of asbestos-containing materials (ACM) left in place. While acceptability varies among local regulators, variances are granted on a case-by-case basis. Noticeable improvements to project schedule and worker safety may result from this approach. Implementation of this approach requires utilization of several engineering controls including worker PPE and respiratory protection, wetting of the structure with amended water, perimeter air monitoring stations, fog cannons and fixatives used to suppress dust, entire quantity of demolition rubble handled and disposed as asbestos waste, and post-demolition soil remediation of job site.

Engineering/Design Indicators of Significance

Environmental controls are not likely to require detailed engineering/design deliverables for the baseline because the scope is usually limited.

Concept Development

Identify the regulatory requirements for demolition. The main regulatory concerns are associated with air emissions and storm water management during demolition, since contaminants could be transported off site via these two pathways.

Development of Baseline

Identify location of storm water drain system inlets that may receive runoff from site during demolition. Determine if typical simple construction site storm water management practices such as of hay bales, silt fence, bags of sand or gravel will be sufficient to control runoff or if more costly storm water structures and/or re-grading portions of the site will be required. Determine method of water application for dust suppression. Develop design for these controls to level of detail for a high confidence baseline.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete design for environmental controls needed during demolition. Provide procurement specifications for materials, equipment, and services.

Activity #38 Site/Civil Activities During and After Final Disposition

This activity plans for general civil engineering activities needed during and after the demolition or in-situ disposal of the facility structure to achieve the final decommissioning end state.

Description

Activities include:

- Maintenance of slope stability
- Backfilling to grade and compaction
- Site re-vegetation
- Permanent storm water control measure installation

In some cases, civil engineering activities will be needed to prepare the site for long-term stewardship. Consider design to minimize long-term maintenance costs.

Engineering/Design Indicators of Significance

Site civil activities are not likely to require detailed engineering/design deliverables for the baseline because the scope is usually limited and methods are well understood construction practices.

Concept Development

Identify any site/civil requirements for the site after final decommissioning compatible with decommissioning end points (Activity #40).

Development of Baseline

Prepare preliminary design in sufficient detail to establish a high performance baseline.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete site/civil design. Provide procurement specifications for materials, equipment, and services.

Activity #39 Closure Configuration

This activity specifies materials and configurations to comply with an agreed upon end state.

Description

Interim or final closure of facilities as part of decommissioning that leaves residual contamination may require some form of containment or monitoring system.

This activity is effectively a design-build function to provide materials and structures to meet the requirements. If significant quantities of mobile contaminants of concern are left at the site after decommissioning, methods of preventing transport of these contaminants off site by infiltration of rain water or ground water flow may be required.

Engineering/Design Indicators of Significance

Closure configuration is not likely to require detailed engineering/design deliverables for the baseline unless achieving the final end state requires an unusually complex final closure configuration. The end state for the majority of facilities will be slab-on-grade. For these facilities, this activity will not be significant. However, for more complex facilities, such as reactor buildings or other massive structures, this activity may be significant.

Concept Development

Identify the containment or monitoring system requirements for the proposed end state.

Development of Baseline

Provide a design for containment or monitoring systems sufficient to establish a high confidence baseline.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Complete the final design. Provide procurement specifications for materials, equipment, and services.

Activity #40 Decommissioning End State and End Points

This activity specifies the facility conditions to be achieved upon completion of a decommissioning project; these conditions include:

- End state, which is a vision of the overall facility status.
- End points, which are the detailed conditions to be achieved upon completion.

Description

Defining the facility end state establishes the high level requirements for conditions to be achieved at completion of a decommissioning. The end state should also address the facility disposition following project completion; for example responsibility transferred to the Office of Legacy Management or closure in accordance with the conditions of the CERCLA ROD.

Decommissioning end points are inherently simpler than for deactivation because the number of conditions to be addressed is very few. Activity #35 addresses verification of decommissioning end points.

Decommissioning end points address as-left conditions to be achieved and can include subjects such as:

- How much of the below grade and above grade structure will remain.
- Grading and water channeling
- Landscaping
- Allowable residual radioactive and hazardous materials contamination, or related criteria that must be met
- Site stabilization
- Utilities and infrastructure that remain

Engineering/Design Indicators of Significance

Specifying decommissioning end state and end points is not likely to require detailed engineering/design deliverables for the baseline because there are usually very few end points and the criteria they must satisfy is defined by well established regulatory practice, such as by CERCLA or DOE O 5400.5.

Concept Development

The decommissioning end state is the primary driver for a decommissioning project. As such, it is derived at CD-0 and will usually be documented in the CERCLA ROD. The case is the same for decommissioning end points at a high functional level.

The decommissioning end state vision and the functional end points should be documented in the CDR and should:

- Describe the end state
- Describes the surveillance and maintenance *concept* that will be in place when the end state is achieved because it may be a driver for developing end points
- Refers to other documentation that specifies the as-left conditions to be achieved for subjects such as listed above

At the concept stage, these specifications are functional in nature. The degree of detail should address “what” the end points should be, but not “how” to implement them.

Development of Baseline

A reliable basis-of-estimate can usually be developed based on the functional description of the decommissioning end points and estimating experience. The detailed design and specifications may occur with sufficient lead-time for implementation by CD-4.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers, and project team that will be conducting the activity.

Ready for Implementation

Implementation of decommissioning end points essentially requires completion of all other project work. Prepare necessary work packages and procedures with sufficient lead-time for implementation by CD-4.

Activity #41 Operations and Maintenance Reduction

This activity reduces the operations, surveillance, and maintenance resources for the facility.

Description

This activity is an example of engineering support for facility operations characteristic of many D&D projects in contrast. Reduction in operations, surveillance, and maintenance can be a result of:

- Reducing the safety category of the facility to Category 3 or Radiological, thereby reducing the needs for A/B required activities
- Eliminating or reducing the need for safeguards and security when nuclear material and classified information are removed from a facility
- Taking systems out of service in the course of deactivation
- Operating systems in a less stressful mode (lower pressure and temperature) or eliminating operational redundancy when no longer required for safety
- Allowing non-safety systems to "run-to-failure" as their that their projected end of life need can be forecast

Some sort of technical evaluation is associated with decisions for each of these actions.

Engineering/Design Indicators of Significance

This activity is not likely to require detailed engineering/design deliverables for the baseline because the related engineering will occur during implementation.

Concept Development

This activity is operational and does not affect the project concept.

Development of Baseline

The baseline elements that include this activity are level-of-effort engineering support for the project.

The potential reduction of resources and associated costs can be estimated on a ROM basis. It is recommended that such reduction be included in the baseline when projecting the operational staffing for the facility over the course of the D&D project schedule.

For most projects, the BOE and the baseline for this activity can rely upon the skill and judgment of the project's engineers, estimators, schedulers and project team that will be conducting the activity.

Ready for Implementation

Implementation of reduction of these activities occurs after CD-3.

Activity #42 Radiological Engineering

This activity includes the analyses and measures aimed at maintaining personnel exposure to radiation as low as reasonably achievable (ALARA).

Description

Radiological engineering reviews are conducted on all activities to be performed in a radioactive environment. Most radiological engineering is conducted during project implementation. It is often the case that physical features such as temporary shielding and ventilation for control of airborne radioactivity are applied at the time of need.

Radiological engineering reviews are used to determine the need for personnel protection that includes:

- Protective equipment, use of shielding, application of fixatives, ventilation for controlling airborne radioactivity, and other contamination control measures.
- Planning work to minimize time of exposure and maintain distance from sources.

This activity is primarily focused on the radiological engineering reviews and analyses that prescribe various control measures. Further development of the various control measures is addressed in detail in the following related activities:

- Surface Decontamination (Activity #13)
- Fixative Application (Activity #14)
- Mockups (Activity #15)
- Shielding (Activity #17)
- Temporary Ventilation (Activity #22)
- Temporary Enclosures and Containments (Activity #24)

Engineering/Design Indicators of Significance

Radiological engineering is not likely to require detailed engineering/design deliverables for the baseline because conducting such analyses is routine practice for field work activities and is a fairly understood process.

Exceptions are in cases where numerous work activities must be performed in areas of high dose rates and/or high contamination levels therefore requiring more detailed reviews and design of various control measures.

Concept Development

Identify what activities will require a radiological engineering review and the level of review that will be needed.

Development of Baseline

With an understanding of the number of radiological engineering reviews that must be conducted, ensure that the project schedule allows adequate time for the conduct of the reviews and ensure sufficient staffing is available to support these reviews.

In cases where work activities will be conducted in high radiation/contamination areas, it will be useful to have the radiological engineering review completed to a point where a good understanding of the type of engineering control measures (e.g., shielding, temporary ventilation, containments, etc.) that will be required for personnel protection. This information is also needed to start the development of the design of the control measures (as detailed in their respective activities).

Ready for Implementation

Final design deliverables are completions of the reviews and "sign-off" of the work packages as appropriate, procurement specifications for materials, equipment, and services should also be prepared at this time.

Activity #43 Trade-off Studies

This activity addresses the analyses and evaluations used for selection of equipment, methods, and/or operational sequences for the various aspects of D&D projects.

Description

Pretty much every decision for how to address the various challenges within a D&D project is based on some form of engineering evaluation. The goal is how to select the lowest cost alternative that maintains personnel safety and protection of the environment while achieving the desired end state within a reasonable amount of time. The evaluations may be based on economics (present worth or total life cycle savings) or cost/benefit and incorporate some form of structured value analysis.

Engineering/Design Indicators of Significance

Performance of trade-off studies is likely to be a significant engineering/design element of baseline development because the selected alternative establishes the approach for achieving the desired end state.

Exceptions are in cases where the evaluations are of a lower tier significance (e.g., selection of fixative A versus fixative B; or selection of waste packaging configuration) and do not greatly affect the overall project scope.

Concept Development

Individual evaluations may be conducted to arrive at technical approach decisions for the various challenges within the project. A set of alternatives to accomplish the end state vision for the activity should be identified and defined to the level of detail necessary to support a sufficiently reliable analysis of costs and impacts with the goal of identifying the optimum alternative for advancement to more detailed planning in the next project phase.

Development of Baseline

Evaluation results are used to decide how to proceed with the project and also to provide input for further development of activities for baselining. However, creating the details for the selected alternative is provided in the conduct of other activities.

Ready for Implementation

Preparation for implementation is not applicable because the results here are provided to other activities.

Activity #44 Reconfigure Security Boundary

This activity reduces schedule impacts on D&D projects resulting from the site's security posture.

Description

D&D of facilities in security areas poses a potential schedule bottleneck with respect to the ingress and egress of demolition equipment and/or waste containers. To alleviate this interference, consideration may be given to reconfiguring the security boundaries (i.e., physically moving fences and guard posts) or to the installation of a dedicated access control point.

Before consideration is given to security boundary reconfiguration, it is necessary to ensure the subject facility is in a configuration that supports a reduction in security classification. This includes removal of SNM inventories/hold-up and/or removal of classified equipment/materials from the facility.

Engineering/Design Indicators of Significance

This activity only applies to facilities located within security areas. Security boundary reconfiguration is likely to be a significant engineering/design element of baseline development because the review and approval process is fairly complex and may require a reevaluation of the site's vulnerability assessment (VA).

Concept Development

Once the D&D project scope is defined and the approach is understood (as detailed in Activity #1), the potential security-related interferences may be identified. Conceptual approaches to alleviate the interferences are identified at this stage. Evaluation of alternatives (as detailed in Activity #43) may be conducted to identify a recommended approach.

Engaging the Security Department early on in the process and keeping them fully involved throughout the development of the project is critical to ensure timely approvals.

Development of Baseline

A clear definition of the security interference(s) and the recommended solution(s) should be fully developed at this stage to allow inclusion of adequate resources in the project baseline. It may be necessary to conduct time/motion studies to support development of the solution.

Input to support a reevaluation of the site VA will also be needed to support the approval process.

Generation of marked up plot drawings and photographs depicting the boundary reconfiguration or new access control point should also be developed at this stage.

Ready for Implementation

Complete the final design. Provide procurement specifications for materials, equipment, and services. Revise security procedures and incorporate security protocols into D&D work packages as necessary.

Activity #45 Waste Treatment

This activity addresses large-scale waste treatment campaigns.

Description

Some waste streams from D&D projects (either legacy materials or newly generated waste) may require a significant amount of treatment to make them acceptable for disposal. Examples include solidification of fuel basin sludge; passivation of reactive wastes (e.g., sodium bearing waste); and ion exchange/filtration of liquid wastes.

Design considerations for a waste treatment campaign include:

- Selection of the use of vendor services or in-house treatment
- For in-house treatment, selection of the use of portable skid-mounted systems or existing in-plant systems
- In-plant systems may require refurbishment or modification to support this campaign
- Provisions for process control and quality assurance to satisfy disposal facility WAC
- Physical method of feeding waste to the treatment system
- Mode of operation (batch or continuous feed)
- Compatibility of final waste form with transportation and disposal regulations
- Contamination control and protection of operating personnel.

This activity is focused on large-scale treatment campaigns; waste conditioning to satisfy packaging requirements is addressed in Activity #29.

Engineering/Design Indicators of Significance

The determination of significance is a function of the magnitude of the quantity of waste requiring treatment and the degree of complexity of the treatment. In most instances this will be a significant engineering/design element of the project because waste treatment entails a lot of up-front design work.

Concept Development

As part of Waste Identification and Planning (Activity #28), all waste streams anticipated from the D&D project scope will be identified along with an intended disposition pathway. Those wastes requiring treatment will also be identified. At this stage of the project, possible treatment alternatives should be identified for consideration.

Development of Baseline

To support baseline development it will be necessary to determine the treatment approach (i.e., vendor services versus in-house treatment; skid-mounted system versus in-plant system). This determination may be conducted as trade-off studies (as detailed in Activity #43). Unique waste streams may require waste treatability studies to aid in process selection and/or determining system design parameters.

Engineering to support use of vendor services includes:

- Specify system capacity/through put (flow rate)
- Specify system location and configuration
- Specify utility interfaces
- Determine method of feeding waste to the treatment system

- Specify contamination control measures and containments (Activity #24)
- Sketches and marked up photographs as necessary

Engineering to support use of existing in-plant systems includes:

- Determine system functionality and identify any refurbishment or modification needs
- Specify modifications at the component level
- Marked up drawings, photographs, and equipment lists to identify modification details
- Identify any special precautions for personnel safety

For decisions to construct a new waste treatment system/facility, the engineering/design review should follow DOE O 413.3A guidance for design-build projects.

Ready for Implementation

Implementation development includes:

- Completion of all design activities from above
- Details of technical requirements that must be included in creating work packages and operating procedures
- Process Control Procedure to ensure final waste form meets disposal site WAC
- Procurement specifications for materials, equipment, and services.

Activity #46 In-Situ Decommissioning Grouting/Void Fill Analysis

This activity addresses the filling of void spaces within facilities to ensure that the Performance Assessment conditions are maintained during the projected life of the entombed structure.

Description

In-Situ Decommissioning (ISD) is the permanent entombment of facilities, typically robust hardened structures physically suitable (or can be made suitable) for permanence. This generally includes the separation process canyons and production reactors, and possibly other structures of similar design.

Filling of void space in structures for ISD serves the dual purpose of stabilizing the structure to prevent subsidence and to immobilize residual contaminants. The introduction of fill materials also impedes infiltration of water and limits access to intruders. Several materials can be utilized for bulk fill including grout, controlled low-density fill, soil, sand, or gravel. “Controlled low-density fill,” also called “flowable fill,” refers to self-compacting, cementitious material with properties similar to Portland cement-based grout. Grout and controlled low-density fill are the more common choices and hence the focus of this activity.

Design considerations include:

- Specification of the grout mixture to provide the desired degree of flowability to ensure proper filling of void spaces
- Identification of filling locations (including the need for penetrations in walls, floors and tanks, etc.)
- Venting of expelled air and the need to provide filtration for contamination control
- Filling in “lifts” to ensure proper curing of the grout
- The method by which filling of void spaces will be verified.

Engineering/Design Indicators of Significance

This activity only applies to facilities that will have an ISD end-state. Grouting and void fill analysis for ISD structures is likely to be a significant engineering/design element of the project based on the sheer magnitude of the effort to fill the large void volumes associated with these structures.

Concept Development

Once it has been determined that a facility will have an ISD end-state, negotiations with regulators should be initiated to determine the final facility configuration including the need for void fill. At this stage of the project decisions should be made on what type of void fill material will be utilized. Scoping calculations should be performed to determine the approximate quantity of fill material needed.

Development of Baseline

Engineering to support ISD void fill includes:

- Specify the type of grout to be used; different formulations are used for different applications (e.g., general area filling, “nooks and crannies” filling, and pipe fill)
- Specify whether grout will be prepared by an on-site batch plant or delivered in cement trucks from a local supplier
- If an on-site batch plant is utilized, specify the design parameters and utility interfaces
- Determine grout placement methods and fill locations (e.g., through existing penetrations or through newly cut access holes)

- Provide marked up drawings showing fill locations
- Specify need for deployment tools (e.g., feed hoses, long-handle tools to manipulate fill nozzles); consideration of remote deployment devices may be necessary when access is limited due to excessive radiation levels (technology development is addressed in Activity #16)
- Identify venting locations and specify filtration requirements for expelled air to control spread of contamination

A Grout Fill Plan will need to be developed; this plan will identify the type of grout to be used and how it will be placed in the facility, as specified by the above engineering design activities. The Grout Fill Plan will also specify:

- The actual filling sequence in engineered lifts, location by location
- Grout delivery rate and pressure
- Curing time between lifts
- Target for remaining void after grout fill (with supporting calculations)
- Methods used to ensure maximum fill is attained (e.g., visual observation in person or through the use of video cameras, rotometer air probes, deliver grout in meter quantities based on engineering calculations)
- Level of independent verification (for closure certification requirements).

Ready for Implementation

Complete the final design for all activities from above. Finalize the Grout Fill Plan and secure necessary approvals. Provide procurement specifications for materials, equipment, and services.

Activity #47 In-Situ Decommissioning Cover Systems

This activity addresses the final closure configuration of facilities with an ISD end-state.

Description

Several configurations are being considered for the final closure of ISD facilities. The general concept includes an engineered barrier consisting of several layers of various materials. Structural fill soil may be mounded around the structure to support the engineered barrier and to provide a combination of resistance, drainage, and evapotranspiration. An engineered closure cap provides three primary functions:

- Provides physical stabilization of the closed site
- Minimizes infiltration of surface water so as to minimize the migration of contaminants to underlying aquifers
- Serves as an intruder deterrent to prevent a person who might inadvertently enter the area after active institutional controls have ended from being able to contact buried radioactivity.

Design of a cover system or final closure cap is driven primarily by site-specific climate conditions, the physical configuration of the item to be covered, and to some extent by stakeholder interests. The configuration of a cover system should serve to maintain the assumptions and results of the Performance Assessment.

Engineering/Design Indicators of Significance

This activity only applies to facilities that will have an ISD end-state. Final closure of ISD structures is likely to be a significant engineering/design element of the project based on the complexity of the structure and the cover system to be utilized.

Concept Development

Identify a closure configuration that is consistent with the Performance Assessment assumptions and results. Early buy-in from regulators and stakeholders is essential to support timely development of the design.

Development of Baseline

After the closure configuration has been decided on and approved, engineering design can proceed. Engineering at this phase includes:

- Specifying the physical configuration of the closure cap (height, slope, fill material types and thickness, final grade considerations, and cover vegetation)
- Developing drawings depicting the cross-section of the cover system
- Specifying the drainage and erosion protection provisions
- Developing specifications for engineered barrier materials
- Specifying the degree of compaction for fill material
- Specifying the final configuration of the structure (e.g., removal of the top story and/or removal of all external steel appurtenances)
- Identifying the source for, and method of, transfer of fill materials as significant quantities may be required (for perspective, it is estimated that a typical process canyon will require approximately 8.7 million cubic yards of soil fill which will require several hundred thousand truckloads to emplace).

Ready for Implementation

Complete the final design. Provide procurement specifications for materials, equipment, and services.

Activity #48 Authorization Basis Step-Out Criteria

This activity addresses downgrading and Authorization Basis (A/B) and reducing/eliminating Technical Safety Requirement (TSR) controls for a facility as it proceeds to decommissioning.

Description

By the very nature of decommissioning, facility equipment and systems will be removed. It is expected that there will be less reliance on safety systems and other TSR controls as the project progresses and as hazardous substances are reduced. For example, the operational limits imposed on systems, structures, and components (SSCs) to prevent a release of hazardous substance are no longer valid if the material has been removed.

"Step out" refers to the stages when reducing and eliminating such controls can be accomplished; "step out criteria" refers to specific conditions and milestones when reductions can be achieved. Step-out criteria must be proposed to, reviewed by, and approved by DOE during the DSA/TSR review process.

Stepping out of a control means that a control may be retired from the safety basis without formally revising documented safety analysis (DSA) and TSR and re-submitting for DOE approval. If the control is still needed to satisfy life safety or emergency response requirements, it should not be eliminated.

This activity is coordinated with Activity #6, Nuclear Safety Analysis.

DOE-STD-1120-2005, *DOE Standard Integration of Environment, Safety, and Health into Facility Disposition Activities*, Volume 1 of 2 provides guidance related to step out criteria related to decommissioning of facilities.

Engineering/Design Indicators of Significance

Step out criteria are likely to be a significant engineering/design element of a project when the facility hazard category is Hazard Category-2 or Hazard Category-3. (Note: a Hazard Category-1 facility would not be in a D&D mode; also, it is unlikely for Category-2 facilities.)

Concept Development

During concept development, planning is conducted to identify conditions and/or project milestones that are likely criteria for step out. In general, criteria used to determine if it is appropriate to retire a control from the safety basis are:

- Hazardous condition being controlled is no longer present.
- Hazardous substance's physical form has changed to a less dispersible form.
- Hazardous substance quantities are no longer present or have been reduced to the point where the consequences of releases are no longer a concern.

Examples include de-inventory of stored nuclear materials and chemicals or removal of equipment such as process gloveboxes.

Other examples are for specific scheduled milestones. The following has been used for a small reactor facility decommissioning:

- *Stabilization* – Fuel removed; defined as the condition where systems and facility areas supporting fuel storage are no longer needed.
- *Stabilization* – Reactor vessel passive radiological controls; defined as the condition where systems and facility areas supporting reactor vessel radiological exposure controls are established such that the corresponding surveillance/maintenance of the areas/equipment maintaining water level are no longer necessary.

- *Stabilization* – System and equipment decontamination and removal of resulting contaminated waste (solid and liquid); defined as the condition where systems and facility areas supporting the processing and removal of radioactive and hazardous contaminated wastes are no longer needed.
- *Deactivation* – defined as the condition when the facility has been deactivated with equipment placed in and end state such that the corresponding surveillance/maintenance is no longer necessary while waiting decommissioning.

The results at the concept stage should be identification and descriptions of the selected step out criteria for the project.

Development of Baseline

For those step out criteria selected during concept development, activities to develop the baseline could include:

- Evaluating characterization results (e.g., databases, surveys, inventory reports, etc.) related to determining when each criterion will be met.
- Showing on the baseline schedule when each step out criterion is to be achieved and the duration of evaluations and analyses leading to that point on the schedule.
- Estimating the resources required to conduct evaluations and analyses needed to specify the step out criteria.

Ready for Implementation

The conduct of analyses, revising of documents (e.g., TSRs, limiting conditions for operation applicability statements), and establishing the procedures for stepping out will depend on the schedule for when specific step out criteria (conditions and/or milestones) are reached. Most, if not all of the requisite evaluations and analyses will not be conducted prior to CD-3 because information on the conditions to be analyzed (such as quantities and physical state of material holdup) may not be known until some of the cleanout work is completed. The work documents (procedures and work plans) cannot be prepared early until this information is available.

Therefore, unless one of the step out criteria have either already been reached or will be reached soon after CD-3, this engineering work can be deferred to be conducted during implementation.

II - 2. Example Lines of Inquiry

II - 2.1 Lines of Inquiry for the Three Step Process Described in Volume I, Section 4

This section presents example lines of inquiry (LOI) for individual activities determined to be significant.

LOI for Actions Leading to CD-1

Topic	LOI
Step 1: Identify Activities for which Engineering/Design Deliverables are needed.	Has the listing in Appendix II-1 been used to identify activities applicable to the project?
	Have activities been identified that are not included in Appendix II-1 for which engineering/design deliverables are needed?
	Have activities been identified that are variations of those included in Appendix II-1 for which engineering/design deliverables are needed?
Step 2: Identify Activities for which Engineering/Design Deliverables are Significant to the Baseline	Using the checklist in Section 4 or equivalent, have *each* of the activities identified in Step 1 been assessed and *recorded* (using Volume I, Table 2 or equivalent) for being significant to the project baseline?
Step 3: Record Results and Specify Deliverables	Has *each* of the activities identified as significant in Step 2 been described and the anticipated deliverables at CD-1 and CD-2 been specified?
Early Engineering/Design Activities	Have deliverables been completed for the significant activities for which CD-1 products been specified?
	Have engineering/design activities been identified and started for significant activities with CD-2 deliverable that nevertheless will require long lead time or involve a complex set of actions and/or decisions?

LOI for Actions Leading to CD-2

Topic	LOI
WBS (work breakdown structure)	Has *each* of the activities identified as significant in Step 2 been included in the project's WBS?
Schedule Logic For purposes of schedule logic, it is recommended that significant activities be sorted to further identify which of them have a complex set of decisions, analyses, deliverables and interface with other activities.	Has a schedule logic similar to that in Appendix Z been developed for those activities that are considered complex?
Project Schedule	Does the project baseline schedule include all significant engineering/design activities linked to project implementation activities that they support?
BOE (basis of estimate)	Have the assumptions specific to *each* of the significant activities been included in the project's BOE?
Project Estimate	Does the project baseline estimate include all significant engineering/design activities?

II - 2.2 Lines of Inquiry for Individual Engineering Activities

This section presents example lines of inquiry for individual activities determined to be significant for baseline development. They can also be used by project management for internal reviews at any time during the project.

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Alternatives Analyses and Selection	What are the key evaluations that result in project technical decisions? Have these evaluations been conducted with an appropriate mix of project and facility level considerations? Are the results clearly justified and documented in detail (i.e., not generalities)?	Have approved recommendations been translated into project technical requirements at an appropriate level? Have these project technical requirements been incorporated in the WBS and schedule as project activities such as demonstrations, equipment design and procurement, services procurement, and operations?
Deactivation End State and End Points	Is there an end points report that addresses all spaces, systems and major equipment within the scope of deactivation? Are the end points based on stated criteria? Are all end points functionally specified?	Have engineering/design details been developed for individual end points that include configuration drawings/sketches, component and material selection, and requirements for how they are to be implemented?
Post-D&D Surveillance & Maintenance	Has a general S&M scenario been developed, such as walk through paths for a deactivated facility? Have the results been used as drivers in the end points report?	Have modifications been identified, if any, that will be needed to support S&M after deactivation or decommissioning? Have the designs been developed for such modifications?
Process System Deactivation and Isolation	Are all isolation points identified for process systems to be deactivated? Have criteria been identified for residual contamination upon shutdown and isolation?	Do the isolation requirements refer to the site lock-out/tag-out (LO/TO) program/procedures? Where isolation is by means other than standard LO/TO, have implementation methods been documented? Are the cleanout requirements specified?
End Points for Operable and Mothballed Systems and Equipment	Have systems to remain operable or mothballed been identified? Do any systems require reconfiguration or a changed mode of operation to support the deactivated facility?	Have reconfiguration or operating mode changes, if any, been engineered and documented?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Nuclear Safety Analyses	Has the plan for facility downgrade addressed all locations where significant special nuclear material exists? Is a facility upgrade needed for D&D operations, and if so, have the requirements been identified? Has guidance in DOE-STD-1189, *Integration of Safety into the Design Process*, been used for approaches to nuclear safety analyses?	Have analyses to support the downgrade (or upgrade) been conducted with thoroughness, the results clearly justified and documented, and traceable to the activities for which they were conducted? Is there a project procedure for conduct of nuclear criticality safety evaluations?
Facility Condition Assessment	Have the structural conditions of the facility been used to identify detailed analyses to be conducted in support of D&D activities and for worker safety? Are there documents that relate the radiological and hazardous material conditions of the facility to projected waste types and quantities?	Have identified analyses been conducted and mitigating actions specified? During review of Activity #28, Waste Identification and Planning, verify that identified radioactive and hazardous materials of the facility itself have been considered.
Characterization of SSCs and Process Materials Likely to be Disposed as Waste	Has a characterization plan been prepared to address SSCs and process materials likely to be disposed as waste? Is it thorough? If sophisticated technology, such as remote access, is needed for characterization, has the interface with characterization planning been thorough? Is it likely that residual nuclear material or contamination is present? If so, have the concerns in DNFSB 2007-1, *Safety-Related In-Situ Nondestructive Assay of Radioactive Materials*, been addressed?	Have the characterization plan requirements been included in the baseline including activities to measure, sample, analyze, and report data? Have requirements and specifications for technology needed for characterization been prepared? During review of Activity #28, Waste Identification and Planning and Activity #29, Waste Conditioning and Packaging, verify SSCs likely to be disposed of as waste have been considered.
Characterization for Compliance	Have the characterization needs for compliance with personnel safety, end points verification, waste management, and regulations been included in the characterization plan.	Have these characterization needs for demonstrating compliance been included in the baseline including activities to measure, sample, analyze, and report data?
Equipment Dismantlement and Removal	Has the scope of equipment requiring dismantlement and removal been identified?	Have engineering deliverables for major equipment dismantlement and removal been developed at a component level-of-detail?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Size Reduction	Has the scope of equipment requiring size reduction been identified?	Have engineering deliverables for size reduction been developed at a component level-of-detail? Are size reduction support facilities, indirect activities, and consumables included in the baseline?
Liquid Flush and Drain	Is there a plan for one or more flush and drain campaigns that comprehensively addresses the issues discussed in Activity #12 in Section 1? For drain campaigns, have the methods to verify completion been documented? For flush campaigns, have the completion criteria (such as allowable residual concentrations of contaminants) been documented?	Have marked up drawings and/or photographs of all individual pipe segments, isolation points, and location of vents and drains been created? Have isometric drawings been created where a complex system is to be gravity drained? Have engineering details of pumps, tanks, valves, and controls been created for flush campaigns? Have engineering calculations been conducted to size the flush components that are not part of the original system?
Surface Decontamination	Has the need for surface decontamination been justified? Have the likely methods been recommended (mechanical, chemical and application methods)? Has it been determined if proof of performance is needed by testing the recommended methods? Are criteria stated for completion of surface decontamination?	Where special equipment and tools are needed for decontamination, have they been specified? If machines or fluid systems are needed for decontamination campaigns, have engineering/design details been developed, including design drawings/ sketches, material selection, and requirements for installation?
Fixative Application	Has the scope of fixative application been identified? Have the types of fixatives to be used been recommended?	Where special equipment and tools are needed for applying a fixative, have they been specified?
Mockups	Have mockup needs been identified? For a major mockup, has it been planned as subproject with functional requirements specified?	Have engineering/design details been developed for each major mockups, including design drawings/sketches, component and material selection, and requirements for how it is to be fabricated and set up?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Technology Application	Have individual technology development/adaptation needs been identified? Have evaluations been conducted/vendors and experts consulted to select the likely candidate technologies to be adapted? For each technology need, has a project been defined to conduct proof tests and/or demonstrate how it is to be applied for this project?	Are results available from prototypes or other means to demonstrate how a technology can be successfully applied for the specific project need? Assuming it has is concluded that implementation will be successful, are the engineering deliverables for implementation available or planned?
Shielding Design	If there is shielding needs other than that which can be handled with portable shielding, have the analyses been conducted to recommend placement, dimensions and materials?	Have structural engineering/design details been developed for shielding, including design drawings/sketches, material selection, and requirements for installation?
Building Structural Integrity	Have a review been conducted to determine if there are structural integrity issues with regard to worker safety and removal/demolition? Based on the results of this review, have structural analyses been conducted to address identified issues?	Where structural integrity is a threat to personnel safety, have engineering/design details been developed to protect against or mitigate the conditions; including reinforcing, if needed? Has a structural assessment for building demolition been conducted and results incorporated in demolition planning, Activity #36 (Demolition Method and Sequence). Have engineering/design details been developed for backfill and slope stability after demolition?
Temporary Electrical Service	Has the scope of temporary electrical needs been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for temporary electrical, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Replacement Electrical Service	If needed, has the scope of replacement electrical system been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for replacement electrical, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Ventilation Modifications	If needed, has the scope of ventilation system modifications been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for ventilation modifications, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Temporary Ventilation	Has the scope of temporary ventilation needs been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for temporary ventilation, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Breathing Air	If needed, has the scope of breathing air system needs been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for breathing air including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Temporary Enclosures and Containments	If needed, has the scope of temporary enclosures and containments been identified? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for temporary enclosures, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Hazards Analysis	Does the project's hazards analysis address both typical and extraordinary hazards (i.e., hazardous conditions or materials for which the project's staff has little experience)? When there are extraordinary hazards, have evaluations been conducted and/or experts consulted to address how to deal with them? Are these solutions documented for engineering/design, procedural, and administrative implementation?	When recommended, have engineering/design details (including design drawings/sketches, component and material selection, and installation requirements) been developed to protect against or mitigate extraordinary structural, mechanical, electrical, chemical, or radiation hazards and hazardous conditions? Have technical specifications been created for procurement of equipment needed to deal with extraordinary hazards and hazardous conditions?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Hazardous Material Abatement	Has the scope of abatement been identified? Have the types and quantities of all hazardous materials been identified? Where access for removal of hazardous material is difficult, have evaluations been conducted and solutions recommended?	Where access for removal of hazardous material is difficult, have engineering/design details been developed (including design drawings/sketches, component and material selection, and installation requirements) to implement the recommendations.
Liquid Waste Management	Has the scope of liquid waste management been identified? Have evaluations been conducted to determine system performance requirements? If new or temporary systems are required, have the functional requirements been stated?	Have engineering/design details been developed for liquid waste management systems, including design drawings/sketches, component and material selection, and requirements for how they are to be installed?
Waste Identification & Planning	Has a comprehensive waste management plan has been created that addresses type, quantity, generation rates, conditioning, packaging, transport, and disposal? If waste management is judged to be more than a few percent of the project costs, has a Waste Management element been included in the WBS? If not, why not?	Have the results of the plan been used to conduct Activities #29 (Waste Conditioning & Packaging), #30 (Waste Staging), and #31 (Waste Transport & Disposal).
Waste Conditioning & Packaging	If needed, have waste conditioning and packaging needs been evaluated and functional requirements stated? Have evaluations been conducted to determine performance requirements?	Have engineering/design details been developed for waste conditioning systems, including design drawings/sketches, component and material selection, and requirements for how they are to be installed? Have engineering/design details been developed for special packaging needs, including design drawings/sketches, component and material selection, and requirements for how they are to be fabricated?
Waste Staging	If needed, have waste staging needs been evaluated and functional requirements stated?	Have engineering/design details been developed for configuring indoor or outdoor staging locations, including design drawings/sketches, component and material selection, and requirements for how they are to be constructed?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Waste Transport & Disposal	Have waste transport needs been evaluated and functional requirements stated? Have evaluations been conducted to determine performance requirements? Have aspects of waste transport that require use of standard or fabrication of custom components been identified?	Have engineering/design details been developed for fabrication of custom components that include design drawings/sketches, component and material selection, and requirements for how they are to be fabricated?
Facility Isolation	Has isolation of the facility been specified, either directly or as part of the end points planning and implementation? Have the functional requirements been stated fore each aspect of facility isolation?	Have engineering/design details been developed for individual isolation locations that include configuration drawings/sketches, component and material selection, and requirements for how they are to be implemented?
Temporary Roads and Access Ways for Heavy D&D Equipment	If needed, has the scope of temporary roads and access ways been evaluated?	Are there drawings that show temporary roads? Are the technical requirements documented for these needs?
Temporary Water for D&D	If needed, has the scope of temporary water needs been evaluated? Have evaluations been conducted to determine needs requirements?	Are there design documents for providing and connection temporary water?
Completion Verification Survey	Have the functional requirements for the completion survey been documented?	Are the methods specified for verification of decommissioning and to meet the decommissioning end points, in Activity #40?
Demolition Method and Sequence	Has a comprehensive demolition plan been created and related structural analyses been conducted?	Have the plan and structural analyses results been used to create a demolition sequence? Have the plan and structural analyses results been used to develop contract specifications for a demolition contractor? Have reinforcement needs, if any, been designed?
Environmental Requirements and Controls for Open Air Demolition	If needed, has the scope of environmental requirements for open air demolition been identified?	Have the requirements and specifications been documented for contamination control, surveys during demolition, waste staging and removal, and meteorological monitoring,

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
Site/Civil Activities During and After Final Disposition	Has the scope of site-civil works needs been evaluated and functionally stated?	Are there drawings that show infrastructure modifications and/or new or temporary installations to support D&D? Are the technical requirements documented for these needs?
Closure Configuration	Has the post-decommissioning closure conditions described in CERCLA documents been translated into functional requirements for features remaining below grade, for structures remaining above grade, if any, and for backfill and grading?	Have requirements and specifications been documented for these features? Are landscaping requirements specified?
Decommissioning End State and End Points	Has the decommissioning end state been included in the CDR? Are the decommissioning end points identified and based on stated criteria? Are the decommissioning end points linked to closure configuration and completion verification survey?	Are technical requirements for decommissioning end points explicitly stated?
Operations and Maintenance Reduction	Is the shutdown of systems reflected in the project schedule?	Is the resource reduction in need for O&M support over time reflected in the baseline?
Radiological Engineering	Has radiological engineering been conducted to assess the radiological impact of design or operational activities where personnel exposure is potentially significant?	Have the results of radiological engineering assessments and recommendations been incorporated in design or operational processes?
Trade-off Studies	For a selected study or Value Engineering task, have recommendations been used to define the scope and objectives of a subsequent engineering activity?	For a selected study to arrive at a solution for a specific engineering or design detail, has the conclusion been implemented in the engineering/design activity?
Reconfigure Security Boundary	Has the concept for reconfiguring security boundary fences, detection systems, and other technical aspects been conducted and recorded?	Have the requisite design deliverables (functional specifications, drawings, procurement specifications, etc.) for security boundary reconfiguration concepts been produced?
Waste Treatment	Have treatment alternatives been evaluated for waste streams requiring treatment?	Have the treatment system design deliverables been produced?

Type of Activity	Initial Level of Detail at CD-1	Increased Level of Detail at CD-2
In-Situ Decommissioning Grouting/Void Fill Analysis	Have the types and quantities of void fill materials been estimated?	Have the design deliverables been produced for fill material specifications and methods of placement?
In-Situ Decommissioning Cover Systems	Has a closure configuration been defined? Has the magnitude of materials been estimated?	Have the design deliverables been produced for the cover system?
Authorization Basis Step-out Criteria	For facilities that are Hazard Category 2 or 3, have step-out conditions and/or schedule milestones been identified?	For a step-out criterion that has been reached (conditions or milestone), have the related requirements been reduced or eliminated?

II - 3. EXAMPLE PROJECT

II - 3.1 Example Project Description

To provide an example for applying the method in Section 4, a fictitious project is presented for deactivating and demolishing a relatively small experimental reactor facility. In this example, the project's three phases include:

- Deactivation Phase: the facility described below is to be prepared for a two-year period of post-deactivation period of low cost S&M consistent with maintaining the facility in a safe condition.
- Post-deactivation S&M phase: the S&M mode will have a skeleton crew that work on day shift for 5 days-a-week. Electrical power is to be maintained and systems required for safety will remain operable.
- Demolition Phase: All facilities and systems, above and below grade are to be removed and the site is to be cleaned up to free-release standards.

The overall strategy is that deactivation, post-deactivation S&M, and demolition will be planned in detail as one project. That is, the project baseline is to include all three phases.

The method presented in Sections 4 and Volume II, Section 1 of this guide is used to identify engineering/design deliverables needed for the baseline as well as illustrating the increasing level of detail for deliverables at CD-1, CD-2, and CD-3.

II - 3.2 Example Facility Description

The overall function of the facility was the preparation, irradiation, and post-irradiation examination of specimens in a small research reactor. It is geographically located where wintertime sub-zero temperatures are experienced. The site is in the eastern half of the USA and considered a "wet" site; that is, moderately rainy summers, and snow accumulation in the winter. There is *no* on-site waste disposal facility.

All fuel and nuclear materials have been removed; facility hazard classification is Radiological. In addition, comprehensive characterization information and data are available.

Tables 2, 3, and 4 describe the physical facility and conditions for spaces and systems.

Table II - 1 – Example Project Facility Rooms and Spaces

Space	Description	Conditions/Constraints
Main Building	The building is a reinforced concrete structure below grade and steel frame construction above grade. The building footprint is 100 ft. x 60 ft. and extends 35 ft. above grade. The structure has basement rooms that extend 20 ft. below grade, with building foundations below that. These basement rooms surround the lower portion of the reactor tanks and contain systems that supported operations. Connections to and from the reactor tank are in this room.	The main building is connected to an adjacent building that is to remain after demolishing the main building. The connected building contains a machine shop that fabricates precision parts critical to use elsewhere on site. Demolition activities must not affect the machine tool foundations.
Reactor Hall	The reactor hall is 60 ft. x 60 ft. open room with the ceiling at 35 ft. above grade. The reactor tank is enclosed on the sides within a 3 ft. thick, octagonal in plan, reinforced concrete. There is a platform deck above the reactor at 20 ft. above the floor, which is at grade level. The reactor tank extends 20 ft. below grade.	The reactor hall is a radiation controlled area. Therefore, the DOE Metals Moratorium applies.
Hot Cell (Specimen disassembly)	A small (10 ft. wide x 4 ft. deep) hot cell is in a corner of the basement. It has a lead glass window and manipulators.	The hot cell was used to disassemble irradiated specimens and is internally contaminated with transuranic and activated metal radionuclides.
Control Room	The control room is on the grade floor adjacent to the reactor hall.	
Electrical Services Room	This room contains switchgear, instrument & control power, and battery backup system.	
Laboratory and Counting Room	A 20 ft. x 15 ft. lab is on the grade floor. It contains 3 hoods, lab benches, and sinks.	The hoods exhaust trunks are contaminated to low levels of radiation.
Hot Machine Shop	The 20 ft. x 15 ft. hot machine shop is on the grade floor. It was used for specimen preparation.	The machine shop contains a variety of contaminated solvents and lubricants.
Maintenance Area	Cold machine shop, I&C and electrical maintenance	
Ventilation Exhaust Filter Room	This room is in a mezzanine area adjacent to the reactor hall. It contains HEPA filters and instrumentation for radioactive zone exhaust ventilation (gloveboxes, hoods, hot cell) as well as emergency filtration from the reactor hall.	The first stage HEPA filters are measurably radioactive.
Waste Packaging Room	A 10 ft. x 15 ft. room at grade level is used to accumulate and package waste prior to removal to a central site staging area.	
Water Processing Room	A room in the basement contains the reactor water cleanup system.	
Service Systems & Equipment Rooms	This room is at grade level and contains the facility service systems such as city water, compressed air, breathing air, and others.	

Table II - 1 – Example Project Facility Rooms and Spaces

Space	Description	Conditions/Constraints
Office Areas	These are administrative areas. They are on a single floor on grade in an annex external, but attached, to the main building.	
Facility Roof and Walls	The above grade portion of the building has Transite siding. The built-up roof contains asbestos.	The roof has been judged as unsafe for workers to manually remove the roofing prior to demolition.

Table II - 2 – Example Project Facility Process Systems and Equipment

System and Equipment	Description	Conditions/Constraints
Reactor	The reactor is a small, open tank, water moderated unit that operated at less than 180° F. All components are still in place except for the fuel, which has been removed from the facility. The reactor tank and components are fabricated of stainless steel.	Waste management will have to consider the classification of activated nickel in the stainless steel.
Specimen Insertion and Retrieval Gloveboxes	A shielded glovebox line is in the basement. The glovebox shielding consists of lead laminated within the glovebox walls. The line extends between the reactor and the hot cell. The gloveboxes were used to prepare specimens for insertion in the reactor and to ferry specimens from the reactor to the hot cell.	The glovebox line internally contains many attached and unattached components. It is contaminated with a variety of radionuclides; possibly with transuranics. The backside of the glovebox line is attached to the basement wall for half its length.
Contamination Zone Exhaust System and Stack	The contaminated exhaust system contains HEPA filters and instrumentation for radioactive zone exhaust ventilation (gloveboxes, hoods, hot cell) as well as emergency filtration from the reactor hall. The exhaust fans are in a small annex exterior to the main facility at the base of the exhausts stack. The exhaust stack is a 1 ft. diameter, guy wire supported fiberglass pipe that extends to a height of 20 ft. above the roof.	The first stage HEPA filters are measurably radioactive.
Reactor Water Cleanup	This system consists of filters and demineralizers for processing the reactor water. These components are contained within individual shielded cubicles with labyrinth entrances. In addition to pumps, valves, and other typical components, there are two 1,000 gallon staging tanks, one is for contaminated water from the reactor tanks and the other is for clean makeup water to the reactor.	The filters and demineralizers read in the range of 20 to 100 mRem/hr.
Reactor Water Cooling	Closed loop system that circulates water to the reactor tank. It is cooled by the component cooling water system via a shell and tube heat exchanger.	
Floor Drains and Sump Processing	The building sump and sump pump system is in a corner of the basement. The sump is periodically pumped through a cartridge filter system and the water is disposed by solidification with concrete in 55-gallon drums. This system also collects laboratory drains.	Radioactivity is low. The sump contains small amounts of sediment and sludge. The filter cartridges can be manually removed without significant personnel exposure.

Table II - 3 – Example Project Facility Support and Service Systems and Equipment

System and Equipment	Description	Conditions/Constraints
Supply Ventilation	Maintains supply air to the entire facility.	None
Heating system	Heat is provided by individual room electric heaters throughout.	None
City Water	Provides water for the wet pipe fire suppression system as well as general water services.	None
Fire Protection (Suppression and Detection)	Consists of a wet pipe fire protection system with smoke and heat detectors. It is supplied by the city water system.	Must be protected from freezing.
Electrical Power Distribution	Switchgear room that provides 480 VAC and 120 VAC throughout the facility.	The building contains a distribution panel that provides 480 VAC power to the adjacent facility. The step-down transformer from the 4KV distribution is in the yard external to the facility. It is close to the building, so it may have to be relocated or replaced prior to demolition
I&C and Reactor Control	Regulated 120 VAC and 28 VDC systems for reactor controls, uninterruptible power supply (including batteries and static inverter)	None
Diesel Generator and Diesel Fuel Storage Tank	Provides backup 480 VAC to the switchgear room. The storage tank has five days capacity with the supply ventilation system and reactor shutdown.	None
Component Cooling Water	Circulates water through a small cooling tower to cool the reactor water cooling system via the common shell and tube heat exchangers	None
House Air/Instrument Control Air	Consists of a compressor, filter/dryer, and receiver system operating at 100 psig.	None
Communication (phones, paging, IT services)	Provided by site systems.	None
Sanitary Effluent	Connects to the site sanitary waste system from the building bathrooms, clean sinks, and clean area sumps.	None

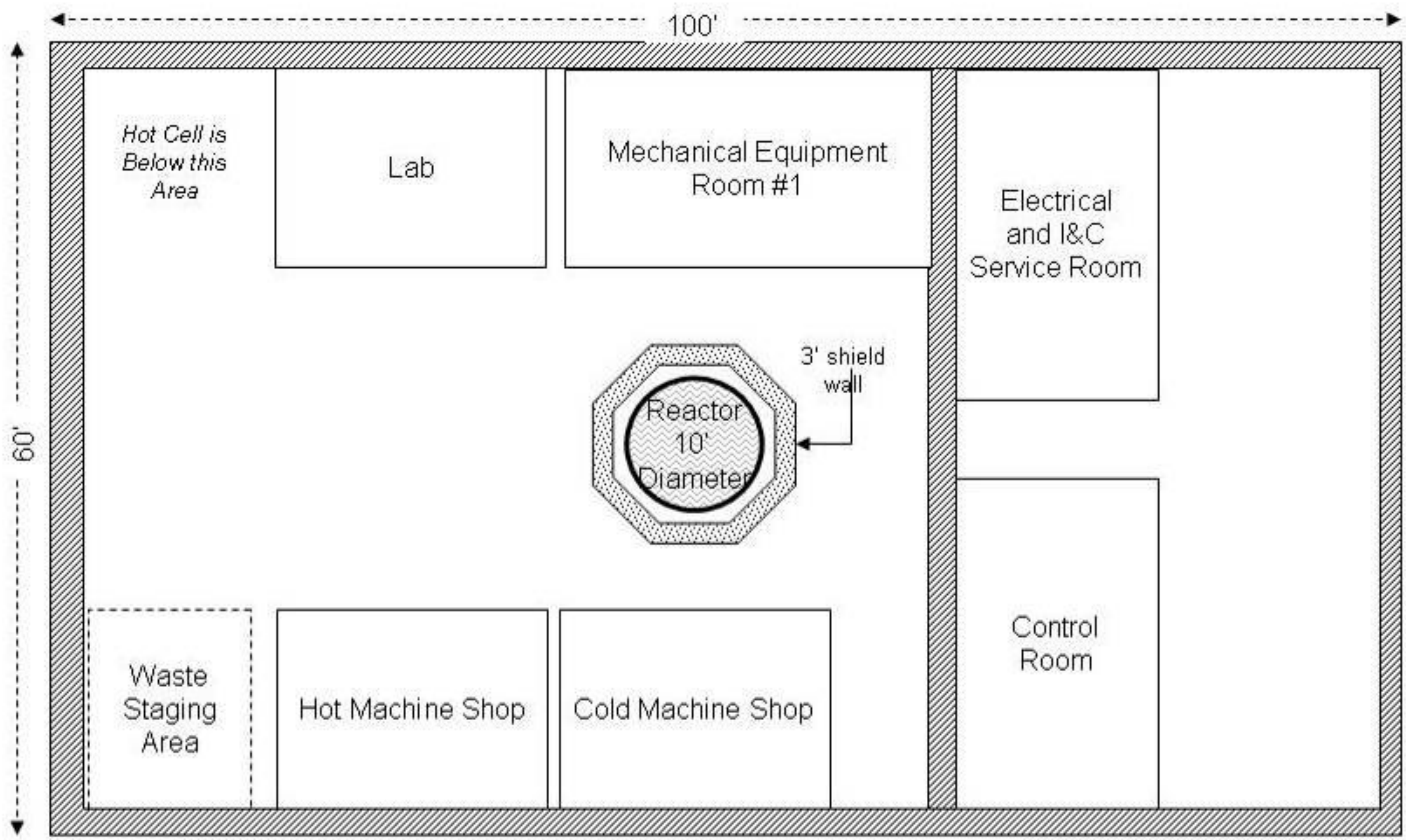

Figure II - 1 – Example Facility Grade Floor

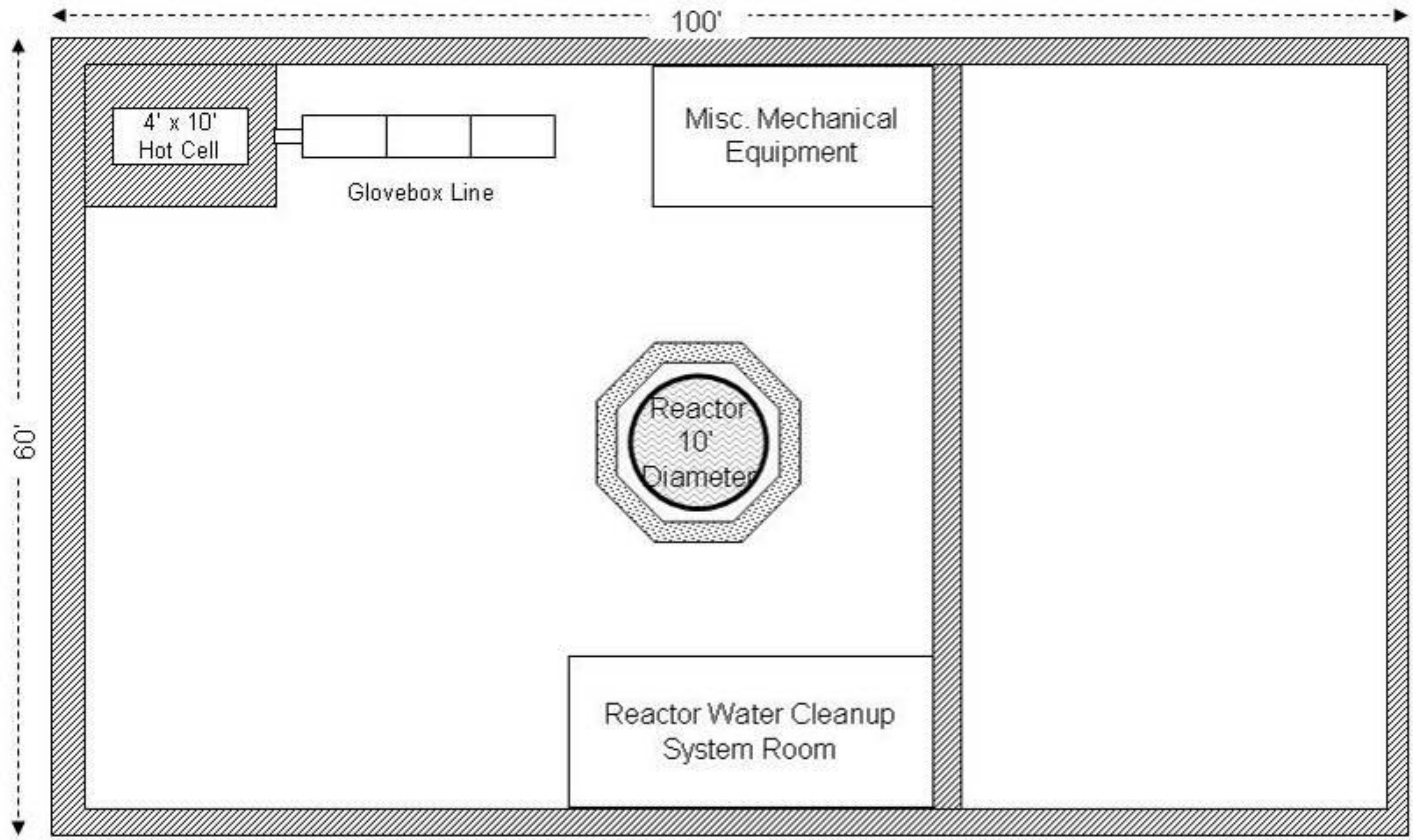

Figure II - 2 – Example Facility Basement Arrangements

II - 3.3 Example Project Significant Engineering/Design Activities

The example project CD-0 decisions and technical strategy that has evolved while developing the overall conceptual design provide the bases for selecting those project activities judged to be significant; that is, significant with regard to the need for detailed engineering/design deliverables to support the baseline. The overall strategy is that deactivation, post-deactivation S&M, and demolition will be planned in detail as one project. For deactivation, key aspects of this strategy include the following considerations:

- The facility will not be deactivated to a “cold and dark” condition because water will remain in the reactor tank and in the fire protection system during the cold winter. The primary objective of deactivation is to reduce staff needs and to isolate systems no longer needed.
- The ventilation system will be modified to exhaust only; the Supply Ventilation will be shut down. This decision reduces further the chances of an inadvertent release of contamination to the environment, especially in light of the facility not being continuously occupied.
- Electrical power to the adjacent facility will be re-routed during deactivation and the external transformer will be relocated or replaced. Electrical power to the reactor facility will be maintained during and following deactivation until a time prior to demolition when all operable systems can be shutdown.
- The fire protection system, which is a wet pipe system, will remain operable until just prior to decommissioning.

For decommissioning, the following are key considerations:

- The major challenge is disassembly and removal of the reactor structural elements and internals, which are underwater.
- Size reduction and packaging the resulting waste will be conducted within the facility.
- A decision is needed whether to process the large amount of water in the reactor tank with the installed system or with vendor supplied skid mounted systems.
- Entry to the hot cell will be required to clean out loose items and to prepare it for demolition.
- Access within the gloveboxes will be needed to clean out loose items and for preparation for removal.
- Because of the sensitivity of the connected building that will remain operational, a very detailed analysis is required of the best way to separate the two before demolition.
- The DOE metals moratorium will have a significant impact on the ability to dispose of structural steel that might otherwise be considered non-radioactive.
- In the interest of worker safety, permission will be sought to not abate the roof materials prior to demolition. This will require technical justification.
- The facility will be removed to a “green field” end state.
- Open air demolition will be the baseline approach for final building removal. The building will have to be decontaminated and surveyed, as needed, to free-release it prior to demolition.

With these strategic decisions Table II - 4 summarizes the bases for deciding which activities required detailed engineering/design deliverables to support the baseline. Table II - 4 emulates Table 2 in Volume I, Section 4. The first forty-one activities in Table II - 4 are the same as in Section 1. Activity #42, “Hot Cell Preparation for Demolition,” has been added for this project.

II - 3.4 Example Project Lessons Learned

In creating this example, the authors ended up reconsidering those activities judged to be significant with regard to detailed engineering/design deliverables for baseline development. As discussed in the body of this guide, the criterion for *not* being significant is when the baseline can rely upon the skill and judgment of the project's engineers, estimators, schedulers and not require such detail. This criterion was revisited several times, eventually reducing the significant activities in this example from fifteen to ten based on the following:

- Activities #9, "Characterization for Compliance" and #17, "Shielding Design" significance was determined to be specific to and integral with other activities; thus not requiring a designation as significant.
- Activity #12, "Liquid Flush and Drain" was initially perceived to be complex until it was understood that the liquid system is small and although the reactor tank is large, the water is not expected to be very contaminated, if at all.
- Activity #29, "Waste Conditioning & Packaging" was initially perceived to be complex until it was understood that the vast bulk of material to be packaged is size-reduced metal and solid waste from radiological controls; for which conditioning and packaging are straightforward.
- Activities #4, "Process System Deactivation and Isolation" and #5, "End Points for Operable and Mothballed Systems and Equipment" were initially included because they are needed early in the project schedule; however, the details are not needed for a reliable baseline. This does not mean that such engineering development is not needed early for reasons other than the baseline.

In addition, it became clear that:

- Activity #11, "Size Reduction" needed to be addressed in two separate activity sheets because size reduction of gloveboxes is considerably different from the reactor tank.
- Activity #42, "Hot Cell Preparation for Demolition" was added because there was no comparable activity in Section 1.

Overall, this exercise of creating a fictitious facility with typical D&D challenge and then evaluating the significant activities for baseline development demonstrated that the process in Section 4 can be a useful planning tool.

A final word of caution is appropriate. This fictitious example is based on a limited mixture of challenges from past projects. It should not be considered anywhere near complete in comparison with a similar project in the field.

II - 3.5 Example Project Activity Sheets

An activity sheet to identify engineering/design deliverables at CD-1, CD-2, and CD-3 is provided following Table II - 4 for each of eleven activities judged significant. A modified form of Table 3 in Section 4 is used for the activity sheet format.

Table II - 4 – Example Project Activities Bases for Significance

Type of Activity	Bases for Significance or Not	Significant
1. Alternatives Analyses and Selection	The decision under CD-0 has been made. It is for complete removal of the facility and restoration of the site to unrestricted release. Details of the post-decommissioning site condition have been specified.	
2. Deactivation End State and End Points	End points are a major driver for deactivation activities.	√
3. Post-D&D Surveillance & Maintenance	S&M following deactivation is straightforward; most process systems will be shut down and most support systems will remain operable. There will be no S&M following decommissioning as the End State is free release.	
4. Process System Deactivation and Isolation	Details are needed for earliest deactivation activities. However, the limited number of process systems in this facility makes this a straightforward activity, except for the reactor structure, which is addressed in Activity #10, and the glovebox line, which is addressed in Activity # 11.	
5. End Points for Operable and Mothballed Systems and Equipment	Because of the climatologic conditions, with the exception of Supply Ventilation and Component cooling water, it is envisioned that the systems in Table II - 3 will remain operable following the deactivation phase of the project. There will be no mothballed systems or equipment.	
6. Nuclear Safety Analyses	The facility has been cleaned out of nuclear materials and is categorized as “Radiological.” Therefore, no further nuclear safety analyses are required.	
7. Facility Condition Assessment	The facility is well characterized prior to CD-0	
8. Characterization of SSCs and Process Materials Likely to be Disposed as Waste	This information and data is needed to understand the overall waste management picture.	√
9. Characterization for Compliance	There is a need to understand the requirements for TRU characterization because of contamination in the hot cell and glovebox line. Characterization of the hot cell is included with Activity #42; the reactor internals with Activity #10; and the glovebox line with Activity #11.	
10. Equipment Dismantlement and Removal	Underwater disassembly and removal of the reactor structure and internals is very complex.	√
11. Size Reduction	Challenges include a complex glovebox line and the large reactor tank.	√

Table II - 4 – Example Project Activities Bases for Significance		
Type of Activity	**Bases for Significance or Not**	**Significant**
12. Liquid Flush and Drain	The liquid waste processing system is small and straightforward; draining the reactor tanks is also straightforward.	
13. Surface Decontamination	Decontamination will be planned and conducted on an as-needed basis.	
14. Fixative Application	Fixatives will be used for the reactor tank, glovebox line, and hot cell. Their use is considered in other activities or will be planned and conducted on an as-needed basis.	
15. Mockups	The design of a mockup is needed for tool selection and configuration for reactor structure and internals disassembly.	√
16. Technology Application	All work can be completed with state-of-the-art and readily available technology.	
17. Shielding Design	May be needed for access to the hot cell access, but is considered in Activity #42	
18. Building Structural Integrity	Separation from connected building presents structural challenges	√
19. Temporary Electrical Service	Facility power will remain available until final stages of demolition.	
20. Replacement Electrical	Moving/replacing the transformer, cable re-routing, and new switchgear for service to the adjacent building is well understood.	
21. Ventilation Modifications	There are no physical components added or removed. Operational configuration change is addressed under operable system end points.	
22. Temporary Ventilation	To be included with temporary enclosures and planning for specific activities.	
23. Breathing Air	The need for independent breathing air is not anticipated.	
24. Temporary Enclosures and Containments	Planning is conducted in other activities. Enclosures are procured and fabricated on an as-needed basis.	
25. Hazards Analysis	See abatement below, which is the only unusual hazardous situation.	
26. Hazardous Material Abatement	The unsafe roof presents a unique challenge for asbestos abatement.	√
27. Liquid Waste Management	A large volume of water will be removed from the reactor tank. However the operation to remove and dispose of the water is straightforward.	
28. Waste Identification & Planning	The DOE metals moratorium presents a unique challenge because of the large quantity of metal. The potential for activated nickel in the reactor internals also must be addressed.	√
29. Waste Conditioning & Packaging	Waste materials for the most part are metal and radiological controls waste. It and other solid waste is not expected to require conditioning other than size reduction, which is addressed in other activities. The amount of process waste, such as demineralizer media is expected to be small.	
30. Waste Staging	The on-site area will be used.	

Table II - 4 – Example Project Activities Bases for Significance		
Type of Activity	**Bases for Significance or Not**	**Significant**
31. Waste Transport & Disposal	These are well-understood activities for the waste management group.	
32. Facility Isolation	Will be detailed on an as-needed basis. The only significant challenge is handled with Replacement Electrical, Activity #20.	
33. Temporary Roads and Access Ways for Heavy D&D Equipment	Existing access is sufficient	
34. Temporary Water for D&D	City water is available.	
35. Completion Verification Survey	This is a well defined process	
36. Demolition Method and Sequence	The connection to the adjacent facility calls for detailed understanding of separation prior to demolition.	√
37. Environmental Requirements and Controls for Open Air Demolition	The facility will be free-released prior to demolition.	
38. Site/Civil Activities During and After Final Disposition	These are standard operations.	
39. Closure Configuration	The facility is to be completely removed.	
40. Decommissioning End State and End Points	The facility is to be completely removed and no residual contamination is expected. It will be minimal and readily removed if found.	
41. Operations and Maintenance Reduction	Will be accomplished during deactivation	
42. Radiological Engineering	This will be addressed with individual specific project scope activities	
43. Trade-off Studies	This will be addressed with individual specific project scope activities	
44. Reconfigure Security Boundary	Facility is not in a security area.	
45. Waste Treatment	No special treatment will be required other than standard waste packaging to meet transportation regulation and disposal site WAC.	
46. In-Situ Decommissioning Grouting/Void Fill Analysis	N/A – Facility to be demolished	
47. In-Situ Decommissioning Cover Systems	N/A – Facility to be demolished	
48. Authorization Basis Step-out Criteria	All fuel and nuclear materials have been removed.	
49. Hot Cell Preparation for Demolition	Must be cleaned out, perhaps decontaminated, and fixative applied so that it can be demolished prior to building demolition.	√

Activity #2 – Deactivation End State and End Points

Activity Title and Description:

2. Deactivation End State and End Points

This activity specifies the physical conditions to be established upon completion of deactivation for spaces, systems, and major equipment listed in Tables 2, 3, and 4 above. End points also specify the administrative conditions; for engineering/design this relates mostly to documentation, such as procedures, that remain as is, are retired, or are modified.

Engineering/Design Indicators of Significance:

End Points are a major driver for deactivation activities.

Concept Development Engineering/Design Deliverables (CD-1):

- A comprehensive *End Points Report* similar to that described for Activity #2 in Section 1. The deactivation End State for this example project, will be one in which the facility's support systems remain operational until preparation for demolition begins. Specifics:
- Particular emphasis is placed on isolation of process systems, reconfiguration of the exhaust ventilation, and conditions to be established for the reactor/reactor tank, the glovebox line, the hot cell, and the laboratory areas.
- The conceptual planning for electrical modifications (Activity #20 above) requires a schematic to indicate the rerouting and the results of an evaluation to move or replace the transformer.
- A decision is needed whether to continue processing the large amount of water in the reactor tank during deactivation, and if so, to use the installed system or replace it with a vendor supplied skid mounted systems (Activity #12).
- Engineering has responsibility for administrative end points for documentation related to post-deactivation operation and maintenance of the facility and its systems.

The S&M vision should recognize that the facility would be staffed during day shift of the normal work week.

Activity #2 – Deactivation End State and End Points

Development of Baseline Engineering/Design Deliverables (CD-2):

- Specification for the configuration of each system that is to be shut down (Activity #4).
- Specification for the conditions to be established for the hot cell (See Activity # 42 below).
- If a vendor supplied, skid mounted process water system is to be used in lieu of the installed process water system, its interface design and procurement specifications are developed (Activity #27).

Timing of the project activities dictates that some detailed engineering deliverables need to be developed early for several deactivation activities; they are:

- Specification for the configuration of each system that is to be shut down, physical modifications (if any), and locations, methods, and materials for mechanical and electrical isolation.
- Requirements for the glovebox line cleanout and isolation (Activity #4).
- Specification for the reconfiguration of the ventilation system and other operable systems and major equipment (Activity #5). The engineering challenge primarily relates to balancing air flow and room pressure when the supply air is terminated and only the exhaust remains operational. The primary deliverables include an analysis of the air flows.

Detailed design for the reconfiguration of the electrical system to supply the adjacent building (Activity #20). This will require a one-line diagram, detailed conductor specification and routing diagrams, terminal diagrams, transformer specifications if being replaced, conduit and cable tray arrangements, building penetration details, bills-of- materials, and other typical deliverables. If a new transformer is to be installed, specifications for procurement are also needed early.

Since the reason for early details is project timing and not significance with regard to development of a reliable scope, cost, and schedule baseline, the CD-2 deliverables are not identified in this Activity #2. They are checked in Table II - 4 as significant for the above activities and elaborated with each.

Ready for Implementation Engineering/Design Deliverables (CD-3):

- Completion of details of how systems and spaces are to be reconfigured or isolated.
- Completion of details for electrical system reconfiguration.
- Checklist and procedure requirements for verifying end points have been met, such as visual inspection, leak testing of blank flanges and fittings, zero voltage checks of deenergized equipment, etc.
- Procedure requirements for installing and testing the reconfigured electrical system (Activity #20).

Activity #8 – Characterization of SSCs & Process Materials Likely to be Disposed as Waste
Activity Title and Description: **8. Characterization of SSCs and Process Materials Likely to be Disposed as Waste** This activity addresses characterization of SSCs to provide input to waste management activities (#27 through #31); specifically to establish waste profiles for compliance with disposal site WAC and transportation regulations and to ensure that all wastes generated have a defined disposition pathway.
Engineering/Design Indicators of Significance: This information and data is needed to understand the overall waste management picture.
Concept Development Engineering/Design Deliverables (CD-1): As input to Activity #28 (Waste Identification and Planning), it will be necessary to identify all the major SSCs, process materials, and residues that will be removed and require disposal and to identify the type and extent of characterization that will be required to ensure proper disposition. For this example project the significant items to be addressed include: • Reactor tank, reactor supports, and reactor internals (further addressed in Activities #10 and #11b). • Hot Cell and contents (further addressed in Activity #42). • Glovebox (further addressed in Activity #11a). • Hot Machine Shop equipment and stored solvents & lubricants. • HEPA filters in ventilation system. • Water Cleanup System filters & demineralizers. • Laboratory benches, hoods, and sinks. • Building sump sediment. • Surfaces of building structure and shield wall (for determination of extent of activation, if any).

Activity #8 – Characterization of SSCs & Process Materials Likely to be Disposed as Waste

Development of Baseline Engineering/Design Deliverables (CD-2):

A comprehensive waste characterization plan should be developed to address the characterization activities for all the items identified above. The characterization plan should include all the elements that are described for Activity #8 in Section 1. For this example project, specific details should also be provided for:

- Obtaining underwater gamma scans and/or NDA samples of the reactor tank, supports, and internals. The plan should specify the deployment apparatus and special features of the counting equipment that will be required. Characterization efforts need to be coordinated with Activity #10.
- Analysis of reactor components activation over the operating life of the facility. Primarily to quantify the amount of nickel isotopes (specifically Ni-63).
- Analysis of samples from the Hot Cell and Glovebox for TRU constituents. Characterization efforts for these areas need to be coordinated with overall plans for Hot Cell demolition preparation (Activity #42) and Glovebox removal (Activity #11).
- Obtaining gamma scan profiles (for example, with ISOCS) for the Water Cleanup System filters & demineralizers.
- Obtaining representative samples of the sump sediment; although radiation levels are expected to be low enough to allow "hands-on" sampling, special deployment tooling may be required to address physical accessibility and collection of a representative sample.

Details from the activities presented in the characterization plan should be used to formulate cost and schedule information to be incorporated into the project baseline for each project activity where SSCs or process materials will be removed or where waste will be generated.

Ready for Implementation Engineering/Design Deliverables (CD-3):

In addition to completion of the activities started in CD-2, detailed characterization work packages for each item identified at the CD-1 stage as requiring specific characterization should be complete and ready to work. Characterization work packages should be of sufficient detail to facilitate implementation with a high degree of confidence that the acquired data will be of such quality to support subsequent waste management decision making. The work packages should include procedures for performing characterization activities, drawings and sketches to identify exact location for acquisition of samples or survey readings, specification of equipment to be utilized and instructions for proper operation of this equipment, identification of the number and size of samples to be acquired, and the necessary provisions to ensure worker safety.

Specifications should also be prepared for procurement of laboratory services, equipment, and any special tooling identified above.

Activity #10 – Equipment Dismantlement and Removal

Activity Title and Description:

10. Equipment Dismantlement and Removal

This activity is for disassembly and removal of the reactor components, activated internals, and its support structure within the reactor tank.

Engineering/Design Indicators of Significance:

Underwater disassembly and removal of the reactor structure and internals is very complex.

Concept Development Engineering/Design Deliverables (CD-1):

Clearly the methods for removal of reactor components and its support structure depend greatly on how it was initially fabricated and assembled; the locations of mechanical connections versus welded connections are important. Physical constraints for conducting underwater cutting must address questions such as:

- Is there a machine available that can be adapted?
- What type of manual cutting can be used?
- Can the water level be lowered and maintain a reasonable radiation exposure rate?
- What is the best sequence for disassembly?
- Should the pieces be loaded into containers underwater? Can divers be used in lieu of deployment from the work platform, which is considerably higher than the bottom of the reactor?
- To what extent should the support structure be removed with the reactor versus later with the reactor tank?

There will be other questions as well; some questions cannot be completely answered until the mockup is available (Activity #15). In addition, there are important considerations that depend on characterization and packaging options (Activities #8, #28, and #29), which in turn depend on the options for staging, shipping and disposal (Activities #29 through #31).

Addressing these will require several engineering studies and evaluations. The results are used to create a detailed disassembly and removal plan. In addition, concept development should identify and functionally specify support system needs.

Activity #10 – Equipment Dismantlement and Removal

Development of Baseline Engineering/Design Deliverables (CD-2):

Activity #10 in Section 1 provides a comprehensive description of deliverables. Specific requirements for this example project would be based on the conceptual phase disassembly and removal plan. Examples of engineering deliverables include:

- Disassembly methods and sequence
- Selection of cutting equipment and mechanical disassembly tools.
- Design of fixtures and other in-tank equipment such as long-handled grippers.
- Design of support systems for water filtration, lighting, rigging for piece-part removal, pool surface airborne contamination control; maybe diver air and decontamination station.
- Design of electrical, hydraulic, and/or pneumatic services, either stand-alone, provided with procured equipment, or from house systems.

The results of exercising potential equipment within the mockup will provide input to these tasks.

Ready for Implementation Engineering/Design Deliverables (CD-3):

Engineering includes:

- Completion of all activities that were initiated for CD-2.
- Procedure requirements for installation of equipment, materials, and systems.
- Procedure requirements for conduct of operations above and within the tank.
- Installation verification requirements.
- Operational checks to test the installations in-situ before use.
- Procurement specifications.

Activity #11a – Size Reduction of the Glovebox Line

Activity Title and Description:

11a. Size Reduction of the Glovebox Line

This activity is for removal of the glovebox line, the contained specimen transfer mechanism and other internal components, followed by size reduction of the gloveboxes to fit into waste containers.

Engineering/Design Indicators of Significance:

Challenges include a complex glovebox line and the large reactor tank, for which this is the first of two activity description sheets.

Concept Development Engineering/Design Deliverables (CD-1):

This activity is coordinated with Activity #8, "Characterization for Waste Disposal," which provides important information regarding how the gloveboxes are to be disposed. It is not anticipated that the internals will be TRU contaminated; however, the data is needed to verify this. If the surfaces are TRU contaminated, then decontamination can be an option for the aim of reducing the contamination to less than 100 nCi/g so that the bulk of the gloveboxes can be disposed as low level waste.

Concept development will:

- Evaluate if the gloves and seals have to be refurbished for cleanout.
- Recommend methods (mechanical, chemical/reagents) for decontamination if it is decided to do so.
- Identify disconnects from power, ventilation, and instrumentation.
- Evaluate if the gloveboxes should be size reduced in-situ or elsewhere on site.
- Evaluate and recommend methods to cut the gloveboxes into pieces for disposal; that is, whether to use torches, saws, other devices, or some combination.
- Identify and functionally specify support system need; e.g., lighting, electrical power, compressed air.
- Address enclosures and temporary exhaust ventilation for control of airborne particulate.
- Assess staging, packaging, and pathways for disposal.

Addressing these will require several engineering studies and evaluations. The results are used to create a detailed size reduction and removal plan.

Development of Baseline Engineering/Design Deliverables (CD-2):

Activity #11 in Section 1 provides a comprehensive description of deliverables. Specific requirements for this example project would be based on the conceptual phase size reduction and removal plan. Examples of engineering deliverables include:

- Size reduction methods and sequence.
- Selection of cutting equipment.

Detailed engineering/design packages are required for:

- Support systems for lighting, electric power and/or pneumatic services.
- Enclosures as described in Activity #24 in Section 1
- Temporary ventilation as described in Activity #22 in Section 1
- Shielding design as described in Activity #17 in Section 1

Activity #11a – Size Reduction of the Glovebox Line
Ready for Implementation Engineering/Design Deliverables (CD-3):   Engineering includes: • Completion of all activities that were initiated for CD-2.   • Procedure requirements for installation of equipment and systems.   • Procedure requirements for conduct of size reduction operations.   • Procurement specifications.

Activity #11b – Size Reduction of the Reactor Tank

Activity Title and Description:

11b. Size Reduction of the Reactor Tanks

This activity is for removal of the reactor tank after: a) the reactor has been disassembled and removed, and b) the glovebox line and attached specimen insertion and retrieval mechanism has been disconnected or isolated.

Engineering/Design Indicators of Significance:

Challenges include a complex glovebox line and the large reactor tank, for which this is the second of two activity description sheets.

Concept Development Engineering/Design Deliverables (CD-1):

This activity is coordinated with Activity #8, "Characterization for Waste Disposal," which provides important information regarding how the tank is to be disposed. During concept development, surface samples should be obtained and analyzed to determine if the tank can be reasonably decontaminated to free-release after removal of water. If this is possible, it affects decisions related to:

- Disposal method (there is a potential for considerable cost savings).
- The need for airborne controls and personnel protective equipment (potential for considerable reduction).
- Demolition sequence with regard to whether the concrete walls surrounding the tank can be demolished with the tank in place.

Concept development will:

- Evaluate and recommend methods to cut the tank into pieces for disposal; that is, whether to use torches, saws, other devices, or some combination.
- Identify and functionally specify support system needs, such as control of airborne particulate, power, and personnel access equipment.
- Assess staging, packaging, and pathways for disposal.

Addressing these will require several engineering studies and evaluations. The results are used to create a detailed size reduction and removal plan.

Development of Baseline Engineering/Design Deliverables (CD-2):

Activity #11 in Section 1 provides a comprehensive description of deliverables. Specific requirements for this example project would be based on the conceptual phase size reduction and removal plan. Examples of engineering deliverables include:

- Size reduction methods and sequence.
- Selection of cutting equipment.
- Design of support systems for lighting, rigging for piece removal, airborne control, and personnel access into the 40 ft. tall tank.
- Design of electrical, hydraulic, and/or pneumatic services, either stand-alone, provided with procured equipment, or from house systems.

Activity #11b – Size Reduction of the Reactor Tank
Ready for Implementation Engineering/Design Deliverables (CD-3): Engineering includes: • Completion of all activities that were initiated for CD-2. • Procedure requirements for installation of equipment and systems. • Procedure requirements for conduct of operations within the tank. • Procurement specifications.

Activity #15 – Mockups

Activity Title and Description:

15. Mockups

A mockup is to be constructed for tool selection and worker training for underwater disassembly and size reduction of the reactor structure and internals.

Engineering/Design Indicators of Significance:

The design of a mockup is needed for tool selection and configuration for reactor structure and internals disassembly.

Concept Development Engineering/Design Deliverables (CD-1):

- Identification of disassembly and size reduction activities to be simulated.
- Fidelity of simulation of the reactor components.
- Lateral physical extent of the mockup with full vertical scale.
- Recommendations as to the types of tools to be tested, modified, and demonstrated.
- Mockup results needed for final design of special fixtures for tool handling.
- Anticipated use of the mockup for training and development later during operations.

Development of Baseline Engineering/Design Deliverables (CD-2):

Engineering deliverables include:

- Requirements documents for the mockup, tools, fixtures, and support systems
- Detailed design drawings of the mockup that includes dimensions, material requirements, and construction details.
- Specification and drawings for support systems (water, lighting, pneumatics, hydraulics, others)
- Fabrication drawings of fixtures to be tested.
- Bill of materials for commercial tools.
- Specifications for fabrication of custom tooling.

It must be recognized that the very purpose of the mockup is to evolve designs of fixtures and tools to be used on the reactor components and therefore the designs provided prior to exercising the mockup will undoubtedly be changed or scrapped for other alternatives.

Ready for Implementation Engineering/Design Deliverables (CD-3):

- Completion of engineering/design from CD-2.
- Test and operations plan for exercising the mockup.

Activity #18 – Building Structural Integrity

Activity Title and Description:

18. Building Structural Integrity

This activity verifies that demolition activities will not adversely impact the structural integrity of the connected structure.

Engineering/Design Indicators of Significance:

Separation from connected building presents structural challenges.

Concept Development Engineering/Design Deliverables (CD-1):

At this stage the scope and reasons for the engineering assessment are stated. Relevant information will be collected as needed to provide input to the analyses. For this example project it has been previously determined that the integrity of the roof is compromised. Analysis will be required to determine the abatement approach (further addressed in Activity #26) and the demolition approach to prevent inadvertent collapse. Planning for demolition (further addressed in Activity #36) will need to take into consideration the effect on the machine tool foundations from the adjacent building. Analyses will be required to identify removal approach and foundation modifications. The structural integrity analysis will also need to address the effects of removal of the Hot Cell (to be removed prior to building demolition as described in Activity #42).

Development of Baseline Engineering/Design Deliverables (CD-2):

The building structural integrity will be analyzed with respect to the issues identified above. Since subsequent project planning is contingent upon the results of the structural analysis, it will be necessary to have this activity completed early in this project phase. The analysis should be documented with results of calculations and recommendations such as sequence of removal and the need for modification or reinforcement to support D&D operations.

Ready for Implementation Engineering/Design Deliverables (CD-3):

Engineering design of any necessary structural modifications should be completed. Deliverables include final drawings (new and marked up existing drawings), loading diagrams, component selection, and procurement specifications for materials, equipment, and services (if needed).

Activity #26 – Hazardous Material Abatement
Activity Title and Description: **26. Hazardous Material Abatement** This activity addresses the removal of non-radiological material hazards (primarily asbestos) for protection of personnel and environmental health and safety.
Engineering/Design Indicators of Significance: The unsafe roof presents a unique challenge for asbestos abatement
Concept Development Engineering/Design Deliverables (CD-1): Using information from the Hazards Analysis (Activity #25) identify the locations where hazardous materials are present and the approach for abatement. For this example project the hazardous materials subject is limited to the asbestos roofing material. If the structural analysis (from Activity #18) confirms that the building roof is unsafe for workers to manually remove the asbestos materials, an alternate approach will need to be developed.
Development of Baseline Engineering/Design Deliverables (CD-2): For this example project it is determined that the building roof will not safely support workers and therefore an alternate approach will be required. It is further assumed that the project will pursue open air demolition of the building with the asbestos-containing roofing in place. In support of baseline development, it will be necessary to acquire a modification (or exemptions) to the air quality permit authorizing the demolition of the building with the asbestos roofing in place. Development of the baseline will also require specification of airborne release monitoring requirements, identification of any limitations (i.e., maximum wind speed during demolition), and specification of fixatives required to minimize particulate releases.
Ready for Implementation Engineering/Design Deliverables (CD-3): In addition to completion of the activities started in CD-2, detailed input to the building demolition work package (discussed in Activity #36) should be completed. The work package should be of sufficient detail to facilitate implementation within the provisions of the modified air quality permit. The work package should identify the necessary PPE required to ensure worker safety, methods by which asbestos-containing materials will be segregated from the demolition debris, and any other actions to be taken to facilitate safe demolition of the structure.

Activity #28 – Waste Identification & Planning

Activity Title and Description:

28. Waste Identification & Planning

This activity addresses all waste sources in the project scope. Emphasis is placed on the two somewhat unique challenges of the DOE metals moratorium and activation of the reactor internals.

Engineering/Design Indicators of Significance:

The DOE metals moratorium presents a unique challenge because of the large quantity of metal. The potential for activated nickel in the reactor internals also must be addressed.

Concept Development Engineering/Design Deliverables (CD-1):

Activity #28 in Section 1 presents the details of what has to be generally addressed. For this example project, the discussion is limited to the two unique issues identified above.

The potential need to dispose of uncontaminated structural steel within the reactor hall because of DOE metals moratorium prohibits recycle of metal that is within a radioactively controlled area during operations. This is a challenge for this project because there is no on-site disposal at this site. The option is for disposal at a construction and demolition landfill, which requires an administrative process of the landfill operator certifying disposal of the material. (The authors here do not know if it is feasible to obtain a variance or to otherwise free-release the materials.) Concept development will require estimating the quantity of materials and identifying the survey methods to show that it the material is not contaminated.

Activated metal components in the reactor internals are a potential problem because the presence of Ni-63 in the stainless steel has the potential to create waste that exceeds Class C disposal limits. Engineering evaluations are conducted to review the reactor operating history with regard to neutron fluence levels and duration combined with decay calculations to estimate the concentration of this isotope. The results should identify if the material, when packaged for disposal, will meet disposal site WAC. If not, the material will need to be identified as an orphan waste and referred to DOE for storage and disposition options.

Development of Baseline Engineering/Design Deliverables (CD-2):

Once the options are understood for these two waste forms, the steps are conducted as described in Activity #28 in Section 1. The deliverable for the baseline will be quantity estimates projected to waste packages and number of shipments. Any special packaging and shipping requirements are identified and if they result in special needs, such as cask shielding or internal fixtures, engineering is conducted to design and specify the components. Engineering deliverables also include analyses to support shipping and/or disposal.

Ready for Implementation Engineering/Design Deliverables (CD-3):

Engineering deliverables include:

- Details of technical requirements that must be included in creating work packages and operating procedures including specifications for management of all waste types to be generated.
- Procurement specifications for materials, equipment, and services.

Activity #36 – Demolition Method and Sequence

Activity Title and Description:

36. Demolition Method and Sequence

This activity establishes the demolition method which will include provisions for open-air demolition with the asbestos roofing materials in place and eliminate interference with the adjacent operating facility.

Engineering/Design Indicators of Significance:

The connection to the adjacent facility calls for detailed understanding of separation prior to demolition.

Concept Development Engineering/Design Deliverables (CD-1):

Concept development includes evaluating and planning the demolition approach taking into consideration the issues identified by the structural analysis (Activity #18). For this example project several key issues need to be addressed, including:

- Detailed understanding of the structural interface with the adjoining facility and how demolition of the foundation can proceed without adversely impacting the stability of the machine tool foundations.
- Demolition of the building with the asbestos roofing materials in place, taking into consideration any special provisions mandated by the modifications obtained for the air quality permit (as addressed in Activity #26).
- The overall sequence of demolition, leading to a succinct project flow that accomplishes the demolition in a controlled manner so as to avoid inadvertent collapse of the building, integrates removal of large equipment (for example, as described in Activity #11b, if the reactor tank can be decontaminated to meet free release criteria it may be decided to remove it as part of the demolition instead of before), and does not interfere with the adjacent facility.

Concept development identifies equipment that will be required to perform the work described above.

Development of Baseline Engineering/Design Deliverables (CD-2):

A detailed demolition plan should be developed and should include all the elements that are described for Activity #36 in Section 1. For this example project, specific details should also be provided for:

- Detailed step-by-step demolition sequence integrated with equipment removal. Specific details of structural component removal sequence and direction of progress should be provided.
- Provisions to mitigate air borne particulate releases from the asbestos roofing materials, including any limitations (i.e., maximum wind speed under which demolition operations may be conducted) as identified by Activities #26 and #37.
- The manner in which demolition will be conducted to minimize interferences with the adjacent facility, including sketches depicting key interface points, clear identification of structural members that must not be disturbed, identification and sequencing of any required structural modifications, and any other special provisions as determined in any of the predecessor activities.

Activity #36 – Demolition Method and Sequence

Ready for Implementation Engineering/Design Deliverables (CD-3):

The demolition plan provides input for the development of detailed work packages and operating procedures that contain the elements that are described in Activity #36 in Section 1. The work packages and operating procedures should be complete and ready to work. The demolition work packages should be of sufficient detail to facilitate implementation with a high degree of confidence that the work can be performed safely and as specified in the demolition plan.

Specifications should also be prepared for procurement (or leasing) of demolition equipment and any special tooling identified above, as well as for procurement of demolition services (if needed).

Activity #42 – Hot Cell Preparation for Demolition

Activity Title and Description:

42. Hot Cell Preparation for Demolition

This activity involves entry, cleanout of items within the hot cell, removal of components that will interfere with demolition, characterization of what remains for purposes of waste disposal, decontamination if needed for dose reduction or waste optimization, and application of fixatives.

Engineering/Design Indicators of Significance:

Must be cleaned out, perhaps decontaminated, and fixative applied so that it can be demolished prior to building demolition.

Concept Development Engineering/Design Deliverables (CD-1):

Concept development includes several technical planning efforts:

- Planning for entry consisting of concepts for enclosures, shielding for personnel protection, and ventilation units to control airborne activity. Depending on construction, entry may require removal of shielded windows.
- Planning for cleanout must first identify all components and items to be removed (they will become waste). For each as applicable, the plan must address surveying (for radiation and contamination), disassembly (including tooling), initial packaging within the hot cell, removal pathways, and staging areas outside the hot cell for packaging prior to removal from the building.
- Planning for final preparation for demolition must address decontamination options (if needed), fixative application (on the walls, ceiling, and floor), and closure of penetrations. This is coordinated with Activity #36, "Demolition Method and Sequence."

Technical concept development is required for:

- Configuration and materials for enclosures.
- Sizing and filtration requirements for local ventilation units to control airborne contamination.
- Type and placement of shielding for personnel protection and for staging of waste.

Activity #42 – Hot Cell Preparation for Demolition
Development of Baseline Engineering/Design Deliverables (CD-2): Detailed engineering/design packages are required for: • Enclosures as described in Activity #24 in Section 1 • Temporary ventilation as described in Activity #22 in Section 1 • Shielding design as described in Activity #17 in Section 1 In addition, a detailed comprehensive task timeline should be developed for the operational phase once the above equipment, materials, and systems are in place.
Ready for Implementation Engineering/Design Deliverables (CD-3): Engineering includes: • Completion of all activities that were initiated for CD-2. • Procedure requirements for installation of the above equipment, materials, and systems. • Procedure requirements for entry and conduct of operations within the cell. • If decontamination is to be conducted, the criteria for when it can cease. • Criteria for fixative placement and sealing of penetrations. • Installation verification requirements for confirming proper installation • Operational checks to test the installations before entry into the cell.

II - 4. Example of Input to WBS and Schedule Logic

This is a complete example of an activity Equipment Dismantlement and Removal (Activity #10) to demonstrate the level of detail that can be developed in support of the guidance. The activity is described, followed by why it might be selected as significant, examples of deliverables at concept stage, baseline development, and ready for implementation. These are augmented with a Work Breakdown Structure (WBS) for the activity and a logic diagram that can be used to develop a baseline schedule.

II - 4.1 Activity Title and Description

This activity identifies and removes equipment from a large process facility to achieve the D&D end points. While it is often beneficial to leave as much equipment as possible for “demolition-in-place” along with the building structure, some items within facility may need to be removed in advance of demolition for a number of reasons, including:

- Nuclear material and/or contamination removal
- Component segregation to ensure conformance to disposal WAC
- Security issues associated with the equipment design
- Packaging for transport to the disposal facility

Planning includes approach and tool selection for equipment removal and/or size reduction, removal path selection, packaging configuration, and any other activities needed to facilitate removal (e.g., flush and drain, structural modifications, application of fixatives, etc.).

II - 4.2 Engineering/Design Indicators of Significance

The facility has a large volume of installed equipment, such as glove boxes, ARC melt furnace, a briquette press, various tooling and machining equipment in the Machine Shop Area, and MG Sets in Generator Room, tanks and piping; Figure II - 3 shows examples. The scope of work to dismantle and remove this equipment is significant, thereby contributing significantly to the project baseline.

In addition, large amounts of excess materials are stored in the facility in a variety of containers and packages. A huge amount of excess equipment is also being stored in the facility. Some of this equipment originated in other facilities, complicating its characterization by process knowledge; Figure II - 4 shows examples.

Figure II - 3 – Examples of Large Attached Equipment

Figure II - 4 – Examples of Unattached Materials

The following checklist provides the basis for designating this activity as significant.

☒	**Based on knowledge of the project, experience, instinct and/or judgment**
☐	**Is indicated as significant in the descriptions in Appendix A in the EM Guidance**
☒	**Is indicated as significant in the activities identified by the project team**
☐	**Requires adaptation or development of technology**
☐	**Has some unique challenge that makes it a first-of-a-kind or one-of-a-kind activity compared with past experience**
☐	**Is operationally complex; for example, difficulty of access, extreme operating conditions (temperature, pressure, flow, chemistry)**
☐	**Is engineering/design-wise complex**
☐	**Requires detailed specifications for procurement of materials and/or equipment**
☐	**Has been identified as a significant project risk element**
☒	**Other reasons:**
	• **This activity has direct impact on several significant project activities, including Characterization of SSCs and Process Materials Likely to be Disposed as Waste (Activity #8), Size Reduction (Activity #11), and Waste Identification and Planning (Activity #28).**

II - 4.3 Concept Development for Key Engineering/Design Deliverables

Conceptual Design Tasks

For the *attached/large equipment*:

- Determine what equipment must be removed prior to building demolition and what makes logical sense to leave for demo-in-place.
- Identify specific items that will require dismantlement prior removal.
- Identify the general condition of each item to be removed, including content (e.g., the presence of liquids, sludge, gas), and contaminants (types and levels).
- Identify the preferred approach (e.g., removal in entirety or size-reduced; removal pathways, and special handling needs) for each item.

For the *unattached equipment and materials*, develop an inventory to quantify and identify what needs to be removed and if any of the items require dismantlement prior to removal. Identify the preferred removal (and disposition) approach and the conditions/contamination levels for all unattached equipment and materials.

Work Breakdown Structure

At this phase of the project, the WBS framework is established based on decisions made during, and the results from, the conceptual development/conceptual design tasks. Decisions to utilize an area cleanout approach versus removal of individual pieces of equipment, or some combination of the two are important to the WBS structure for equipment dismantlement and removal. The WBS would conceivably include unique line items related to: a) cleanout of selected areas of the building, and b) removal of selected items of major attached equipment. This WBS concept is illustrated in Figure II - 5.

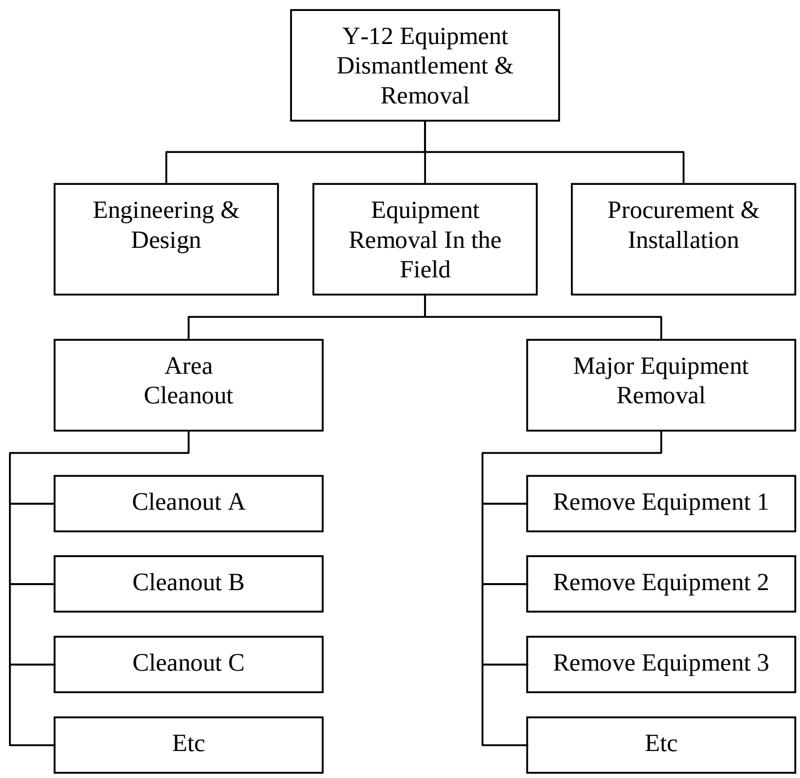

Figure II - 5 – WBS Concept for Equipment Dismantlement and Removal

II - 4.4 Development of Baseline for Key Engineering/Design Deliverables

It might be more efficient to address removal of some of the attached equipment, like the machine shop tooling, with an area cleanout approach since there is a large amount of equipment that will require similar steps to remove. The unattached equipment and materials would also be best addressed by an area cleanout approach. It is assumed that the major complex attached equipment, like the glovebox, ARC Furnace, and various process equipment, will be addressed individually due to the uniqueness of each item. For each item identified in the conceptual development/conceptual design tasks, the project team should develop with sufficient detail:

Equipment Disconnection

Conduct the engineering for disconnection of the equipment from the system/facility where it is located. This includes addressing electrical connections (e.g., power supply and I&C) and mechanical connections (e.g., process flow, compressed air, service or cooling water). Disconnection from equipment pedestals and foundations should also be addressed. Deliverables include:

- Work scope for disconnection
- Marked-up drawings identifying disconnection locations
- Specifications for how each location is to be physically terminated and isolated from it's source
- Test requirements for integrity of terminations and closures

Equipment Draining

Conduct the engineering (as needed) for draining equipment prior to removal (such as oil, cooling water, process liquids, etc.). Flush and drain operations are further addressed in Activity #12. Deliverables related to equipment draining prior to removal include:

- Identification of drain location
- Identification of liquid/sludge removal method
- Collection method
- Marked-up drawings identifying drain location(s)

Equipment Dismantlement/Disassembly

Conduct the engineering for dismantlement/disassembly of the equipment to facilitate removal (or provide access to internals for decontamination or removal of residuals). This includes addressing at a component level-of-detail, the sequence of actions for disassembly and removal and the appropriate type of tools and fixtures that will be required; and addressing whether fixatives or foaming are required. This also includes evaluation of the need, and approach to be utilized, for size reduction. Size reduction is further addressed in Activity #11. Deliverables include:

- Work scope for dismantlement/disassembly/size reduction
- Equipment drawings
- Listing of special tools & fixtures
- Sketches of special tools & fixtures
- Sequence of dismantlement/disassembly/size reduction actions when important

Rigging and Lifting

Conduct the engineering for rigging and lifting to ensure equipment can be safely removed. This includes verification of lifting lug capacity (or design of new lifting lugs if needed), identification of rigging components (e.g., slings and shackles) and special rigging devices (e.g., spreader bar), and lifting zone to ensure there is no interference from other equipment. Deliverables include:

- Calculations for lifting lug design, rigging selection, and crane capacity
- Sketches of rigging configuration
- Lifting & Rigging Plan
- Determination of crane or lifting device (e.g., type, capacity)

- Test load requirements

Setup for Characterization

Prepare the engineering associated with the setup for characterization. Given the diversity of equipment involved and the fact that some of it originated from unknown locations, extensive characterization will be necessary to plan disassembly and removal activities and to determine appropriate disposition pathways. Characterization is further addressed in Activity #8. Deliverables include:

- Specification of location where characterization is to be conducted
- Specification of parameters/radionuclides to be analyzed for
- Identification of required characterization equipment
- Arrangement drawings

Handling and Transport

Prepare the engineering for handling and transport of the equipment within the facility to verify it can be safely removed and transported out of the facility (e.g., over floors and/or roofs, through existing passage ways). This includes addressing packaging needs (or use of fixatives) to control the spread of contamination. Deliverables include:

- Marked up arrangement drawings depicting equipment transport path
- Calculations for floor loading analysis
- Calculations for modifications to existing passageways or design of new passageways.
- Design and specification of contamination control devices/materials
- Design of transport cart or dolly, if required.
- Design for removal of interferences

Disposition Pathway

Identify the disposition pathway, including appropriate packaging and mode of transport. This activity is closely related to Waste Identification and Planning which is addressed in Activity #28. Deliverables include:

- Identification of disposal location
- Identification of packaging configuration
- Identification of transport mode
- Functional requirements for special handling, adapters, inserts, contamination isolation

Staffing Requirements

Identify specialized resource needs, such as rigging craft support and structural engineering support, to ensure availability of personnel with the necessary skills set and to provide input to the development of the project staffing plan which is needed for the baseline estimate.

II - 4.5 Ready for Implementation for Key Engineering/Design Deliverables

At the start of the CD-3 project phase, it is necessary to only identify the set of procedures that will be needed to complete the work as detailed in this activity and to specify what these procedures need to address. The timing for the preparation of the procedures is a project decision and will probably be deferred until the actual work is to be done.

Engineering at this phase includes:

- Completion of all activities that were initiated for CD-2.
- Work sequence/installation instructions and engineering requirements input to work packages and procedures.
- Procedure requirements for installation of equipment, materials, and systems.
- Procedure requirements for disassembly of identified equipment.
- Technical specifications to support procurement for materials, equipment, and services.

II - 4.6 Schedule Relationships

Figure II - 6 shows the logical sequence of activities for this engineering activity. This logic is intended for use in constructing a critical path schedule.

The interfaces with other engineering activities shown in the diagram include:

- Input from: Characterization of SSCs and Process Materials Likely to be Disposed as Waste (Activity #8) – this information is needed to determine the disassembly and removal approach; to determine the need for worker PPE, containments, fixatives and other contamination control measures; and to plan for the disposition for each piece of equipment.
- Input from: Deactivation End State & End Points (Activity #2) – the end points for facility deactivation need to address the extent to which equipment must be removed from the facility prior to demolition.
- Output to: Waste Identification & Planning (Activity #28) – waste generated by removal of equipment and materials from the building need to be included in waste management planning.
- Output to: Size Reduction (Activity #11) – size reduction is closely coupled with equipment dismantlement and removal and should be iteratively developed with it. The selection of size reduction approach and tooling is dependant on the type of equipment that must be removed from the building.
- Output to: Several design activities, including rigging, structural modifications, foam/fixatives process, process system isolation, and liquid flush & drain, as needed to facilitate equipment disassembly and removal from the building.

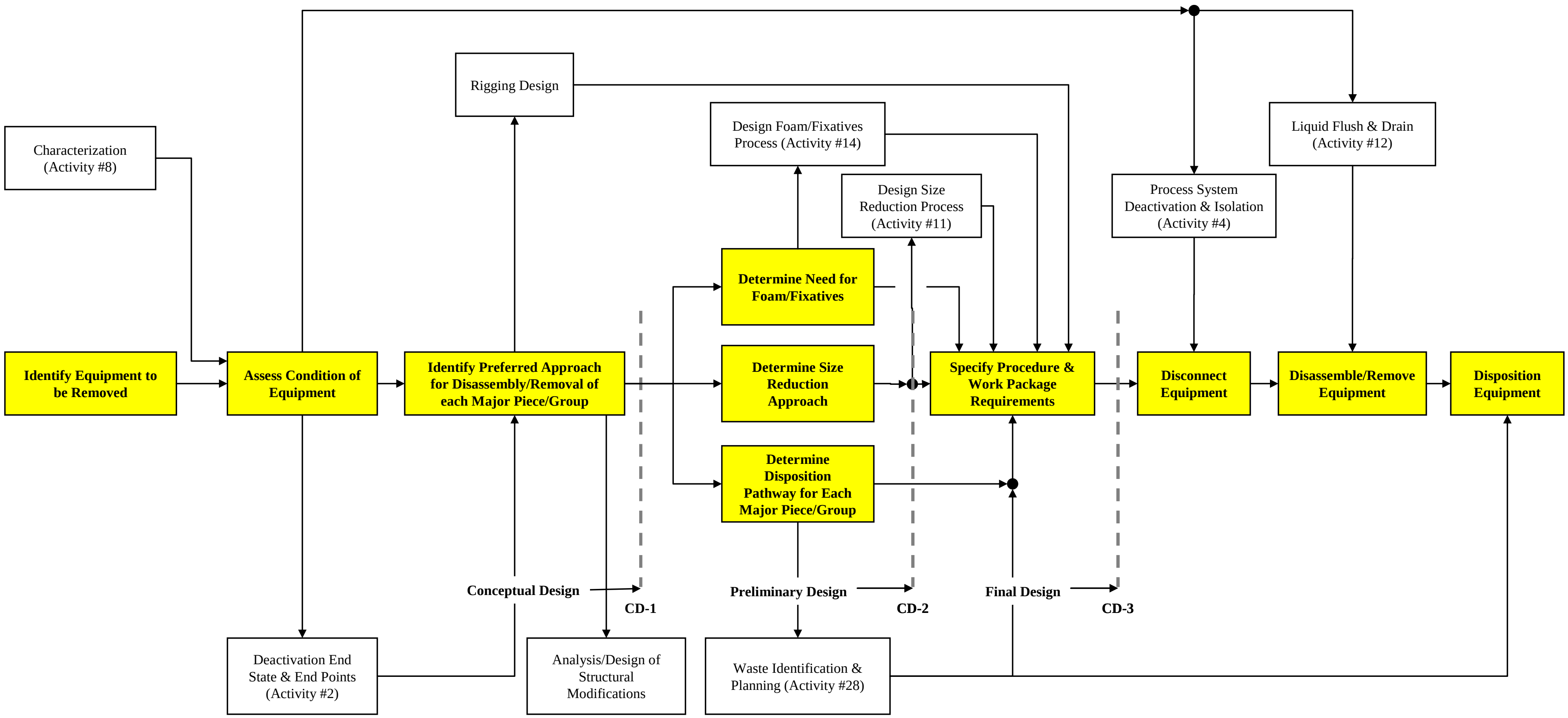

Figure II - 6 – Schedule Logic for Equipment Removal Engineering